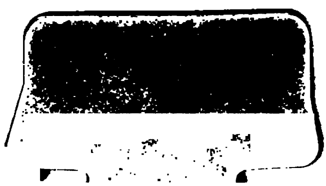

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VOL. VII.

DESCRIPTIVE ANATOMY.

VOL. I.

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DESCRIPTIVE

ANATOMY.

BY

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VOL. I.

LONDON.
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MDCCCXLI.

AUTHOR'S PREFACE.

THE study of man offers three very different objects for contemplation; viz. his organisation, his vital functions, and his moral and intellectual faculties.

The organisation or structure of man is the object of *anatomy* — a science which investigates every distinguishable material condition of the different parts that enter into the construction of his frame. Anatomy is a science of observation, and is, in this respect, susceptible of mathematical precision and physical certainty.

The vital functions of man are the objects of *physiology*, which reveals to us the actions of organs, with whose structure anatomy has previously made us acquainted. The science of physiology inquires into the various motions that occur within the human body, just as anatomy investigates the form of its component parts. All that we know, in fact, concerning material objects, may be resolved into a knowledge of their motions and their forms.

As a moral and intellectual being, man is the object of the science of psychology, which contemplates him in the exercise of thought and volition, analyses the operations of his mind and will, and classifies them according to their supremacy.

A perfect acquaintance with man necessarily presupposes a combination of all that is taught by these three sciences; and it is because his anatomy, his physiology, and his moral and intellectual endowments have not been studied by the same class of philosophers, that in the sciences relating to himself so much yet remains to be desired.

Anatomy—the immediate object of this work—constitutes the foundation of medicine. In order to discover the precise seat of a defect in some complicated machine, and the means to be adopted for the reparation of its disordered mechanism, it is necessary to be acquainted with the relative importance, and the particular action of all its constituent parts. "The human body," says Bacon, "may be compared, from its complex and delicate organisation, to a musical instrument of the most perfect construction, but exceedingly liable to derangement." And the whole science of medicine is therefore reduced to a knowledge of the means by which that harmonious instrument, the human frame, may be so tuned and touched, as to yield correct and pleasing sounds.

But since anatomy forms, as it were, the vestibule of medical science, it is of importance, that he who is entering upon its pursuit should fully understand the path he is about to tread; it is necessary, therefore, to assign, on the one hand, the rank which medicine holds as a natural science, and on the other, the position of anatomy among the various sciences relating to medicine.

The term *science*, according to the admirable definition of the Roman orator, signifies certain knowledge, deduced from certain principles — *cog-*

nitio certa ex principiis certis exorta. Sciences are divided into the *metaphysical*, the *mathematical*, and the *natural;* but since the two former are not connected with our present subject, we shall direct attention to the natural sciences only.

The object of the *natural sciences*, or of *physics*, taken in its widest signification, is a knowledge of the materials of which the universe is composed, and of the laws by which they are governed. They are subdivided into the *physical*, and the *physiological* or *zoological*.

The physical sciences take into consideration all the phenomena presented by inorganic bodies; they comprise, 1. *Astronomy*, which studies the heavenly bodies as they revolve in space, and estimates, by the aid of numbers, the laws by which their movements are governed; 2. *Physics*, properly so called, or the study of the properties of matter in general; in aid of which, experiments are performed in order to exhibit phenomena in every possible light, and calculation is employed to render fruitful the results of experiment; 3. *Geology*, or that science which studies the surface of the globe, and the successive strata which are met with in its interior; which goes back far beyond all historical traditions, brings to light, as it were, the very depths of the earth, and traces with a sure hand the history of the globe, and the various revolutions it has undergone; 4. *Chemistry*, which consists in the study of the reciprocal actions of bodies, when reduced to their atomic condition.

The *zoological* or *physiological* sciences embrace all the phenomena presented by living bodies. The science of *botany* examines into the structure and functions of plants; but *zoology*, properly so called, investigates the organisation and the life of animals. The examination into structure or organisation constitutes *anatomy*. *Physiology* embraces the study of functions or of life.

The facts presented to us in the zoological are of a totally different character from those comprised in the physical sciences. Inorganic bodies, in fact, are governed by constant and immutable laws, acting in perfect harmony with each other; but living bodies are subject not only to physical, but also to vital laws, the latter of which are constantly struggling against the former. This struggle constitutes life; death is the triumph of the physical over the vital laws. In consequence, however, of this continual strife, derangements of structure and disordered functions very often occur; and these become more frequent and more complicated, in proportion as the organisation is more highly developed, and the animal more elevated in the scale of creation.

A knowledge of these derangements and of the proper means for restoring both organisation and life to a healthy condition, constitutes the science of *medicine;* and the station which I have just assigned to this most important branch of zoological science will prove, better than any arguments, that the study of the physiological or healthy state of organisation and of life should precede that of their pathological or diseased conditions; and that anatomy forms the first link in the chain of medical science.

Each science has its own methods of investigation, and its peculiar elements of certainty. Metaphysics and moral philosophy have a metaphysical and moral certainty. The mathematical sciences set out from a small number of self-evident propositions or axioms founded upon the nature of things, proceed gradually from the known to the unknown, and trust to problems already demonstrated as to so many axioms, by means of which, as steps, they again ascend towards new truths. The natural sciences,

again, are founded upon observation, and observation is merely the evidence of our senses; hence arises the necessity of exercising them, in order to increase their acuteness and their activity. Facts, therefore, constitute the elements of the natural sciences; and then reasoning follows, founded upon those facts and upon analogy. It would be absurd to study the natural sciences after the same method as metaphysics.

It may readily be understood, that as the purely physical sciences are based upon constant phenomena, mathematics are directly applicable to them, and hence they are termed physico-mathematical sciences; but in the zoological sciences, effects are continually varying, according to their causes. Any attempts, therefore, to apply the art of numbers to the elements of medicine, would be to imitate the philosopher, Condorcet, who entertained the whimsical notion of subjecting moral probabilities to the test of mathematical precision; who was anxious to substitute $a + b$ for either oral or written legal testimony; who admitted half proofs and fractional proofs, and then reduced them to equations, by means of which he supposed he could arrive at arithmetical decisions, regarding the lives, the fortunes, and the characters of his fellow-men.

It must, however, be reluctantly confessed, that we can acquire a knowledge only of the surfaces of a body; and that to say we are acquainted with its texture, is to state in other words, that we have a knowledge of the smallest surfaces comprised within its general surface. Sight, touch, &c. the only means of investigation by which we can appreciate the qualities of matter in general, can recognise nothing but surfaces, appearances, and relative properties. Absolute properties they are unable to detect. With our organisation, we shall never know of what material objects essentially consist, but only what they are in relation to ourselves.

This work being essentially of an elementary nature, and in some measure adapted for the lecture-room, I have endeavoured to confine myself within narrow limits, and strictly to avoid all considerations which are not immediately connected with the anatomy of organs. At the same time I have not forgotten, that this work was intended for the student of medicine, and not for the naturalist; I have, therefore, been induced, in the following pages, if not expressly to indicate, at least to direct attention to the more immediate applications of anatomy to physiology, surgery, and medicine.

The objects which I have constantly had in view have been to exhibit the actual state of the science of anatomy; to present its numerous facts in their most natural order; to describe each fact clearly, precisely, and methodically; to adopt such a method as would form an easy guide to the student, and not involve him in confusion; and lastly, to give to each detail its peculiar value, by invariably directing particular attention to the more important points, instead of confounding them with matters of less consequence, in an indigested and monotonous enumeration of facts.

The following is the order in which the principal divisions of the subject have been treated.

The first division comprises *Osteology*, *Arthrology* or *Syndesmology*, and *Odontology*.

1. *Osteology*, which, notwithstanding the great number of works on the subject, seems always to offer some new facts to those who study it with zeal, has been treated with the attention it deserves, as forming the basis of anatomical knowledge. An account of the developement of the osseous system has appeared to me necessary for the completion of its history. I have therefore considered the following points in connection with the developement of each bone:— the number of ossific

points; the time of appearance of the primitive and complementary ossific points; the periods at which the several points unite, and the changes occurring in the bone subsequently to its growth. By adopting this method, the most complicated ossifications are reduced to a few propositions easily retained in the memory.

The inconvenience arising from including in a description of the bones all the attachments of the muscles, and nearly the whole anatomy of the part, is so totally at variance with a methodical arrangement of facts, that it is unnecessary to offer an apology for the changes made in this respect. Occasionally, however, I have mentioned those muscular attachments which might serve to characterise the osseous surfaces on which they are situated.

2. Under the title of *Syndesmology*, or *Arthrology*, are united all the articulations of the human body. Assuming as the only basis of classification the form of the articulated surfaces, which is always in accordance with the means of union, and the movements of the joint, I have been induced to modify the divisions usually adopted. The *condylarthrosis*, or *condyloid articulation*, and the articulation by *mutual reception*, form quite as natural genera as the *enarthrosis* and the *arthrodia*. It will, perhaps, be found, that the characters of the different kinds of articulation, and in particular those of the *angular ginglymus*, which I have called the *trochlear articulation*, and those of the *lateral ginglymus*, or the *trochoid articulation* of the ancients, are more clearly defined than in other anatomical works.

The mechanism, *i.e.* the movements of a joint, is so intimately connected with its anatomy, that it was impossible to pass it over in silence; on the other hand, it was sometimes difficult to determine the limit which ought to distinguish an anatomical from a physiological treatise. I have endeavoured to avoid both extremes, by confining myself strictly to the mechanism of each joint in particular, referring to works on physiology for the principal movements of locomotion, and of animal statics, such as walking, running, standing, &c.

3. *Odontology*, or the description of the teeth, concludes the first division. I have taken care to point out that this juxtaposition of the bones and the teeth was founded upon their common indestructibility, and not upon the identity of their nature; the bones being organs composed of living tissues, while the hard portion of the teeth, on the other hand, is but the solidified product of secretion.*

The second division includes *Myology*, *Aponeurology*, and *Splanchnology*.

1. In treating of *Myology*, I have preferred the topographical to the physiological arrangement of the muscles, for this reason only, that it admits of all of them being studied upon the same subject. To unite, as far as was practicable, the undoubted advantages possessed by both methods, I have given, at the conclusion of myology, a general sketch of the muscles, arranged according to their physiological relations; and by grouping them, not after their order of superimposition, but according to their several actions, I have arranged them around the articulations to which they may belong, and have pointed out the extensors, the flexors, &c.

A muscle being known when its attachments are ascertained, I have thought it advisable to commence the description of each by a brief announcement of its origin and insertion, as a sort of definition or summary. The particular details concerning its mode of insertion, whether it be aponeurotic or fleshy, and concerning the direction of its fibres, complete the description of each muscle considered by itself; the history of which is

* See note, p. 234.

concluded by an examination of its relations to neighbouring parts, and of its uses. The individual or combined action of the muscles, for the production of simple movements, follows so naturally after their description, and presupposes so correct and positive a knowledge of their anatomy, that it can be treated of with propriety only in a work on anatomy. The compound movements necessary for the consecutive or simultaneous action of a great number of muscles come within the province of physiology.

2. The *aponeuroses*, those important appendages of the muscular system, are separately noticed, in connection with the muscles to which they belong; but I have also described them together under the head of *Aponeurology*. This combination of analogous parts possesses the twofold advantage of simplifying the science, by enabling one part to elucidate the structure of another, and of permitting us to discover the general laws according to which these structures are disposed.

3. With some modification, I have adopted that old division of anatomy, which treats of the viscera and organs, and which is known by the name of *Splanchnology*.

The brain and the organs of the senses, which were included in this division in all anatomical works preceding those of Soemmering and Bichat, have been removed from it, and described with the other portions of the nervous system. The description of the heart, in like manner, will be found with that of the other organs of circulation. In short, the old classification of the viscera, according to their locality, that is, into those of the head, the neck, the chest, &c. has been replaced by a more physiological arrangement. Splanchnology will therefore comprehend a description of the organs of digestion and their appendages, of the organs of respiration (among which is included the larynx, or the organ of voice), and *lastly*, the genito-urinary organs.

To the inquiry, why I have departed from the usual custom of placing splanchnology at the end of anatomy, I reply that, in order to study, with advantage, the vessels and the nerves, it is necessary to have a previous acquaintance with the organs to which they are distributed.

The importance of the parts described in this division, and the practical results which flow from even the most superficial knowledge of their forms, connections, and intimate structure, are at once my reason and excuse for extending, to so great a length, this portion of the work; and, moreover, it is necessary to state, that there are many medical practitioners who learn anatomy only from elementary works.

The third and the last division treats of *the organs of circulation*, viz. the heart, arteries, veins, and lymphatics; and of the *sensory apparatus*, viz. the organs of the senses, the brain, and the nerves.

1. No part of anatomy, perhaps, has been better known than the arteries, since the appearance of Haller's admirable works; I could neither have followed a better guide nor a more perfect model.

2. The study of the *veins* has acquired an unexpected degree of importance, in consequence of the works of various physicians on phlebitis; and our knowledge of them has been much extended by the researches of M. Dupuytren into the veins of the spine, and the excellent plates of this order of vessels published by M. Breschet.

3. The study of the *lymphatics* has been almost abandoned since the very remarkable publications of Mascagni: I have endeavoured to ascertain what credit was to be given to the assertions of some modern writers, concerning the frequent communication between the veins and the lymphatics.

4. The work of Soemmering on the *organs of the senses*, constitutes perhaps the highest title to fame possessed by that great anatomist; and it might even be said that he has left nothing for his successors to accomplish, did not the constant study of a science of observation unceasingly proclaim this important truth, that it is in the power of no man to declare, beyond this limit thou shalt not pass.

The brain and the nerves, to which so many able and laborious inquirers have lately directed their attention, have been my favourite objects of investigation; on account of their importance, and perhaps, also, from the difficulties attending their study. Not satisfied with simply tracing the nerves to the various organs in the body, I have studied them in the interior of those organs, and have endeavoured to ascertain the precise branches that are distributed to each particular part.

I may add, that, in order to facilitate the dissection of the nervous system, and, indeed, of all the other parts of the body, I have presented, whenever it was necessary, a short account of the best method of preparation.

With regard to the general spirit of this work, I have been anxious to render it classical; and have avoided, most scrupulously, that species of induction and analogical reasoning, which, in a great measure, constitutes philosophical anatomy. To this kind of anatomy, I have never even introduced any allusions, except when its general ideas and views (almost always ingenious, but usually bold and speculative) might elucidate our own subjects.

All the descriptions have been made from actual dissections. It was only after having completed from nature the account of each organ that I consulted writers, whose imposing authority could then no longer confine my thoughts, but always excited me to renewed investigations wherever any discrepancy existed.

Anatomy being, as already stated, the basis of medical science, we should greatly misapprehend its nature, did we not consider it the chief of the accessory sciences of medicine.

Without it, the physiologist rears his structure upon sand; for physiology is nothing more than the interpretation of anatomy. It is anatomy that guides the eye and the hand of the surgeon; that inspires him with that ready confidence, which leads him to search amongst structures, whose lesion would be dangerous or mortal, for some vessel that must be tied, or for a tumour which must be extirpated. Nor is it less indispensable to the physician, to whom it reveals the seat of diseases, and the changes of form, size, relation, and texture, which the affected organs have undergone.

Anatomy is moreover the science which, of all others, excites the greatest curiosity. If the mineralogist and the botanist are so eager, the one to determine the nature of a stone, the other to ascertain the characters of a flower; if the love of their particular science induces them to undertake the most dangerous voyages, in order to enrich it with a new species, what ought to be our ardour in pursuing the study of man, that masterpiece of creation, whose structure, possessed of both delicacy and strength, exhibits so much harmony as a whole, and displays so much perfection in its parts!

And whilst contemplating this marvellous organisation, in which all has been provided and pre-arranged with such intelligence and wisdom, that no single fibre can acquire the slightest addition, or undergo the least diminution of power, without the equilibrium being destroyed, and dis-

order being induced, — what anatomist is there, who would not feel tempted to exclaim with Galen, that a work on anatomy is the most beautiful hymn which man can chant in honour of his Creator.*

May this work inspire among students an ever increasing ardour for the study of the organisation of man, which, even if it were not the most eminently useful, would still be the most interesting, and the most beautiful of all the sciences. And what more powerful motive for emulation can present itself to a generous mind, than the idea, "that every acquisition of knowledge is a conquest achieved for the relief of suffering humanity." Let it never be forgotten that without anatomy there is no physiology, no surgery, no medicine; that, in a word, all the medical sciences are grafted upon anatomy as upon a stock; and that the deeper its roots descend, the more vigorous will be its branches, and the more abundantly laden with flowers and with fruit.

I must here express my acknowledgments to M. Chassaignac, the anatomical assistant to the Faculty, who has distinguished himself in several *concours*, and who has assisted me with the greatest zeal in the execution of this work.

* "Sacrum sermonem quem ego Conditoris nostri verum hymnum compono, existimoque in hoc veram esse pietatem, non si taurorum hecatombas ei sacrificaverim, et casias, aliaque sexcenta odoramenta ac unguenta suffumigaverim, sed si noverim ipse primus, deinde et aliis exposuerim quænam sit ipsius sapientia, quæ virtus, quæ bonitas." (*Galen, de usu part.* lib. iii.)

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DESCRIPTIVE ANATOMY.

INTRODUCTION.

Object and division of anatomy.— General view of the human frame.—Apparatus of sensation—of locomotion—of nutrition—of reproduction.—General plan of the work.

CONSIDERED in its most extended signification ANATOMY * is the science which has for its object the structure of living beings.

Living beings are divided into two great classes, vegetables and animals; there is therefore a *vegetable anatomy* and an *animal anatomy*. When anatomy embraces, in one general view, the whole series of animals, comparing the same organs as they exist in the different species, it receives the name of *Zoological*, or *comparative anatomy*.

Zoological anatomy is denominated *philosophical or transcendental*, when from the combination and comparison of particular facts it deduces general results, and laws of organisation.

When anatomy is confined to the examination of one species only, it receives the name of *special*—such as the anatomy of man, the anatomy of the horse, &c. *Physiological anatomy* considers the organs in their healthy state. *Pathological anatomy* regards them as altered by disease.

When *physiological anatomy* is confined to the examination of the external conformation of organs, that is to say, of all their qualities which may be ascertained without division of their substance, it is called *descriptive anatomy*. If, on the contrary, it penetrates into the interior of organs, in order to determine their constituent or elementary parts, it receives the name *general anatomy*, or of *the anatomy of textures*.

Descriptive anatomy informs us of the names of organs (*anatomical nomenclature*), their number, situation, direction, size, colour, weight, consistence, figure and relations: it traces in fact the topography of the human body. In more than one respect, it is to medicine what geography is to history. The anatomy used by *painters and sculptors* may be regarded as one of its dependencies, and may be defined to be the knowledge of the external surface of the body, in the different attitudes of repose, and in its various movements. On this subject it may be observed, that the precise determination of the external eminences and depressions may afford most important indications regarding the situation and state of deeply-seated parts, and is therefore worthy the attention of the physician.

Descriptive anatomy, in the sense here meant, has arrived at a high degree of perfection. It is to this branch that reference is made by those who affirm that nothing now remains to be done in anatomy. But although descriptive anatomy may be all that the surgeon requires to enable him to comprehend the lesions, which most commonly fall under his notice, and to perform operations, it will by no means suffice for the physician or the physiologist. For their purposes,

* The word Anatomy is derived from the Greek (ἀνὰ, up, and τέμνω, I cut). It is, in fact, by means of dissection principally, that we are enabled to separate and study the different organs. But injections, desiccation, the action of alcohol, concentrated acids, &c. are also means employed by the anatomist.

anatomical investigations must not be confined to the surface, but penetrate into, and analyse the substance of organs. Now such is the object of general or textural anatomy. By its means the different organs are resolved into their component tissues: these tissues again are reduced to their simple elements, which are then studied by themselves, independently of the organs which they form; and subsequently by considering the elementary constituents as combined in various proportions, the organisation of even the most complicated and dissimilar parts is made manifest.

There is one species of anatomy which has of late been cultivated with the greatest success. I mean the *anatomy of the fœtus.*

The anatomy of the fœtus, or the anatomy of the body at different periods of life, named *the anatomy of evolution*, has for its object the study of the development of organs, their successive modifications, and sometimes even the metamorphoses which they undergo, from the time of their first appearance until they arrive at perfection.

Lastly, there is a species of anatomy to which the term of "applied anatomy" may be given, because it comprehends all the practical applications of the science to medicine and surgery. With this view the body is divided into regions or departments, and each region into successive layers. The relation of the different layers is pointed out, and in each layer the parts which compose it. In a word, the constant object is the solution of the following question:— A region, or any part of the surface of the body being given, to determine the subjacent parts which correspond to it at different depths, and their order of superposition. This has generally been denominated the *anatomy of regions, topographical* or *surgical anatomy*, because it has hitherto been studied only with reference to its uses in surgery. It may easily be shown, however, that with exception of the limbs or extremities, the anatomical knowledge of which has few applications to medicine, properly so called, the study of regions is no less important to the physician than to the surgeon. To give it therefore a name corresponding with its use, it should be called *medico-chirurgical topographical anatomy.*

Such are the different aspects under which anatomy may be regarded. The following work is essentially devoted to descriptive anatomy.*

General View of the Human Body.

Before entering on a detailed description of the numerous organs which enter into the composition of the human body, it is advisable to present a rapid sketch of the whole. Such general views, instead of embarrassing the mind, at once enlighten and satisfy it, by exhibiting the objects of its research in their true relations, and showing the end to be attained.

There is one general covering, which, like a garment, envelops the whole body, and is moulded, as it were, round all its parts. This covering is the *skin*, of which the nails and hair are dependencies. The skin presents a certain number of apertures, by means of which a communication is established between the exterior and the interior of the body. These apertures, however, are not formed by a mere perforation or breach of continuity in the skin; on the contrary, this membrane passes inwards at the circumference of these openings, and having undergone certain important modifications in its structure forms the *mucous membranes*, a kind of internal tegument, which may be considered as a prolongation of the external envelope. We might, therefore, strictly speaking, regard the human body as essentially composed of a skin folded back upon itself. This idea is indeed realised in some of the inferior animals, which consist of a mere tube or canal. In proportion however as

* Descriptive anatomy ought in strictness to be confined to the consideration of the external characters of organs, or what is understood by the term *external conformation*; nevertheless, in order to present a complete view of each organ, after having described its exterior, we shall give a short account of its texture and development.

we ascend in the scale, we find the layers which separate these two teguments become more and more increased in thickness, and cavities are at length formed between them. Nevertheless, however widely these membranes may be separated from each other, and however different they may be in external aspect, there are abundant analogies to establish unequivocally their common origin.

Under the skin there is a layer of adipose cellular tissue, which gently elevates it, fills up the depressions, and contributes to impart that roundness of form which characterises all animals, and particularly the human species. In some parts, there are muscles inserted into the skill, which are intended for its movement; these are the cutaneous muscles. In man they are very inconsiderable, and are confined to the neck and face, where they play an important part in giving expression to the physiognomy: but in the larger animals they line the whole skin, and in certain classes, of very simple organisation, they constitute the entire locomotive apparatus.

The superficial veins and lymphatics traverse the subcutaneous cellular tissue: the latter at various parts of their course pass through enlargements denominated lymphatic ganglions, or lymphatic glands, which are grouped together in certain regions.

Below the cellular tissue are the *muscles*, red fleshy bundles arranged in many layers.

In the centre of all these structures are placed the bones, inflexible columns which serve for a support to all that surrounds them. The vessels and the nerves are in the immediate neighbourhood of the bones, and consequently removed as much as possible from external injury. Lastly, around the muscles and under the subcutaneous adipose tissue are certain strong membranes, which bind the parts together, and which, by prolongations detached from their internal surface, separate and retain in their situation the different muscular layers, frequently each particular muscle: these envelopes are the *aponeuroses*.

Such is the general structure of the limbs or extremities.

If next we examine the trunk, we find in its parietes a similar structure, but more internally are cavities lined by thin transparent membranes, named *serous*, on account of a liquid or serosity with which they are moistened. In these cavities are situated organs of a complex structure, called *viscera*, of which we shall give a rapid enumeration in an order conformable to the offices they perform in the animal economy.

The human body, as well as that of other organised beings, is composed of certain parts, denominated organs (*ὄργανον*, an instrument), which differ from each other in their structure and use, but are all combined, for the double purpose of the preservation of the individual, and the continuance of the species.

To accomplish these purposes, the organs are distributed in a certain number of groups or series, each of which has a definite end to fulfil. This end is denominated a *function*: the series of organs receives the name of an *apparatus*. Of those necessary for the preservation of the individual, some are designed to place him in relation with external objects, and these constitute the *apparatus of relation*: the others are destined to repair the loss, which the parts of the body are constantly suffering; they form the *apparatus of nutrition*.

The apparatus of relation may be subdivided into two classes: 1. *The apparatus of sensation*. 2. *The apparatus of motion*.

Apparatus of sensation. The apparatus of sensation consists: 1. *of the organs of sense*; 2. *of the nerves*; 3. *of the brain and spinal cord*.

The organs of the senses are, 1. *The skin*, which possesses sensibility, the exercise of which constitutes tact. The skin being placed under the direction of the will, and rendered mobile in consequence of the peculiar mechanism of the human hand, is called the *organ of touch*. 2. *The organ of taste*, the seat

of which is in the cavity of the mouth, that is, at the entrance of the digestive canal. 3. *The organ of smell*, placed in the nasal fossæ, the commencement of the respiratory passages, by which we are enabled to recognise the odorous emanations of bodies. 4. *The organ of hearing*, constructed in accordance with the principles of acoustics, and placed in relation with the vibrations of the air. 5. *The organ of sight*, which bears relation to the light, and exhibits a construction in harmony with the most important laws of dioptrics.

The organs of sense receive impressions from without. Four of them occupy the face, and are therefore placed in the vicinity of the brain, to which they transmit impressions with great rapidity and precision; and that organ seems in its turn to extend into them — so to speak, by means of the nerves. Indeed the impressions received by the external organs would be arrested in them, were it not for certain conductors of such impressions: these conductors are the *nerves* —white fasciculated cords, one extremity of which passes into the organs, while the other is connected to the spinal marrow and the brain, which are the central parts of the nervous system, the nerves constituting the peripheral part.

Apparatus of locomotion. The apparatus of *locomotion* consists, 1. of an active or contractile portion — the *muscles*. These are terminated by *tendons*, organs of a pearly white colour, which direct upon a single point the action of many forces; 2. of a passive portion, *the bones*, true levers, which constitute the frame-work of the body, and the extremities of which by their mutual contact form the *articulations*: in the latter we perceive (*a*) the *cartilages*, compressible elastic substances, which deaden the violence of shocks, and render the contact uniform; (*b*) an unctuous liquid, the *synovia*, secreted by membranes denominated *synovial*: this liquid performs the office of the grease employed in the wheel-work of machinery; (*c*) bands or *ligaments*, which maintain the connexion of the bones.

Such is the apparatus designed to establish the relation between man and external objects.

Apparatus of nutrition. The apparatus which performs in the human body the important office of nutrition consists of the following parts:

A. The *digestive apparatus*, which consists essentially of a continuous tube or canal, denominated the *alimentary canal*. This canal has not the same form and structure throughout the whole extent: on the contrary it is composed of a series of very dissimilar organs, all however contributing to the formation of one common passage. These organs are, 1. *The mouth*; 2. *The pharynx*; 3. *The œsophagus*, or gullet; 4. *The stomach*; 5. *The intestines*; which are further subdivided into the *small intestines*, consisting of the *duodenum*, *jejunum*, *and ileum*, and the *large intestines*, comprising the *cœcum*, *colon*, and *rectum*.

To this long tube, the greater part of which is contained in the abdomen, where it forms numerous reduplications, are annexed: 1. *The liver*, a glandular organ whose office it is to secrete the bile, and which occupies the superior and right portion of the abdomen; 2. *The spleen*, whose functions are involved in great obscurity, but which may perhaps be termed an appendix to the liver, on the left side; 3. *The pancreas*, which pours a fluid into the duodenum, by an orifice common to it and the biliary duct.

B. On the internal surface of the digestive canal, and particularly that portion of it which bears the name of the small intestine, certain vessels open by numerous orifices or mouths *, and carry off the nutritive fluids prepared by the process of digestion: these are the *chyliferous* or *absorbent vessels*, which are also called *lacteal vessels*, on account of the white milky aspect presented by their contents while absorption is going on. The absorbent apparatus consists also of another set of vessels denominated *lymphatics*, because they contain a colourless liquid named lymph, which they collect from all parts of the body. All the absorbent vessels, of whatever order they may be, traverse at different

* [This must not be understood literally. See account of the lacteals, *infrà*.]

parts of their course certain greyish bodies, called *lymphatic ganglions* or *glands*, and finally terminate in the venous system.

C. The venous system arises from all parts of the body: it takes up on the one hand all those matters which, having been employed a sufficient time as part of the body, must be eliminated from it, and, on the other hand, all those substances which are carried into the system, to contribute to its reparation: it is composed of vessels denominated *veins*, which at various distances are provided with valves, and at last unite in forming two large veins called *venæ cavæ*, of which one, the *superior*, receives the blood from the upper part of the body; the other, *the inferior*, brings back that which has circulated in the lower portion.

These two venæ cavæ terminate in the central organ of the circulation — the *heart*, a hollow muscle, containing four contractile cavities: two on the right side, the *right auricle and ventricle*; and two on the left, the *left auricle and ventricle.*

D. Next to these in order of function is the *respiratory apparatus* composed of two spongy sacs placed on each side of the heart, and occupying almost the whole of the chest: these are *the lungs*. They receive the air from a common tube, *the trachea*, which is surmounted by a vibratile organ, the larynx, which opens externally by the nose and mouth, and constitutes the organ of voice.

E. From that cavity of the heart which is called the left ventricle, arises a large vessel, *the aorta:* this forms the principal and primitive trunk of the whole class of vessels, named *arteries*, whose office it is to convey red blood to all parts of the body, to maintain their heat and life.

F. There still remains one other portion of the nutritive system — *the urinary apparatus*, consisting of, 1. *The kidneys*, organs which secrete the urine: 2. *The ureters*, by means of which the urine, as soon as secreted, passes off into a spacious receptacle, *the bladder*, from whence it is at intervals expelled along a passage which has received the name of *urethra*.

Apparatus of reproduction. The apparatus above mentioned is destined for individual preservation: the organs which secure the continuance of the species constitute the *generative* or *reproductive apparatus*. They differ in the male and in the female.

In the male they are, 1. *The testicles*, which prepare the spermatic or fecundating fluid; 2. *The vasa deferentia*, tubes which transmit this fluid from the testicle where it is secreted to the vesiculæ seminales, 3. *The vesiculæ seminales*, or receptacles of semen; 4. *The ejaculatory ducts*, through which the seminal fluid passes into the urethra; 5. *The prostate* and *Cowper's glands*, glandular appendages of the organs for the transmission of the semen; 6. *The penis*, by means of which the fecundating fluid is conveyed into the interior of the genital organs of the female.

The generative apparatus in the female is composed of the following organs: 1. *The ovaries*, the function of which is to produce, or keep in readiness, the ovulum or germ; 2. *The uterine tubes*, which transmit the germ when fecundated to the uterus; 3. *The uterus or womb*, in which the product of conception remains and is developed during the period of gestation; 4. *The vagina*, a canal which permits the passage of the fœtus at its final expulsion; 5. As appertaining to the system should be mentioned the *mammary glands*, which secrete the milk destined for the nourishment of the new-born infant.

General Plan of the Work.

There are two methods by which the numerous facts that come within the range of anatomy may be explained. The different organs may be studied in their order of superposition or in the *topographic order*, *à capite ad calcem;* in this way the most dissimilar parts are brought together, while others are separated, which have the greatest analogy; or they may be considered in a *physiological order*, i. e. an order founded upon the same grounds as serve for the classification of functions. This is clearly the most rational, because it has the

incontestable advantage of preparing for the study of the functions, by that of the organs. It may be easily seen however that this physiological arrangement should be modified according to the relative difficulty in the study of the different parts of the body; for the great aim in a work of instruction should be to conduct the mind by degrees, from simple and easy objects to those which are more complicated. It is for this reason that the consideration of the nervous system, which in strict accordance with physiological arrangement should be placed near to that of the locomotive apparatus, is deferred. The object proposed has been to adopt an arrangement, which would as far as possible reconcile both these views, and at the same time be compatible with the greatest economy of subjects for dissection; and this appears to be secured by the method generally adopted, at least with a few slight modifications.

The following table presents a view of the general plan of this work:—

1. Apparatus of locomotion	1. Of the bones — Osteology. 2. Of the articulations — Syndesmology. 3. Of the muscles — Myology. 4. Of the Aponeuroses — Aponeurology.	
2. Apparatus of digestion, apparatus of respiration, genito-urinary apparatus	Splanchnology.	
3. Apparatus of the circulation	Heart Arteries Veins Lymphatics	Angeiology.
4. Apparatus of sensation and innervation	Organs of the senses Spinal cord Brain Nerves	Neurology.

APPARATUS OF LOCOMOTION.

OSTEOLOGY.

OF THE BONES IN GENERAL.

The bones — importance of their study. — General view of the skeleton. — Number of the bones. — Method of description. — Nomenclature. — Situation in general. — Direction. — Size, weight, and density of bones. — Figure. — Distinction into long, broad and flat bones. — Regions of bones. — Eminences and cavities. — Internal conformation. — Texture. — Development of Osteogeny. — Nutrition.

The bones are parts of a stony hardness, but yet organised and living. They serve as a support to all other parts of the body, are a means of protection to many, and afford points of attachment to the muscles, in the midst of which they are situated. All the hard parts of the body, however, are not bones. The fundamental character of a bone consists in its being at once hard and organised. As the bones receive vessels for the purpose of nutrition at every part of their surface, they are surrounded on all sides by a membrane which is fibrous and vascular, named the *Periosteum* (περὶ, around; ὀστέον, a bone).

According to this definition the teeth, horns, nails, and in articulated animals the exterior skeleton, are not to be considered as bones, but merely ossiform concretions. We may add that true bones belong exclusively to vertebrated animals.

The study of the bones constitutes *Osteology*, which may be regarded as the basis of anatomy, for without a knowledge of the bones it is impossible to become acquainted with the muscular insertions or the exact relations between the muscles, nerves, viscera and above all the vessels, for which the bones afford the anatomist invariable points of reference. Osteology has therefore

ever since the time of the Alexandrian school, formed the commencement of the study of anatomy.

In the present day, the transcendental anatomists have particularly engaged in the study of the osseous system, doubtless on account of the facility with which it may be investigated; and from their labours, though in many respects speculative, a more accurate knowledge has been obtained of some of the nicer points of osteology. which had scarce attracted notice from the older anatomists.

Lastly, from the admirable researches of Cuvier respecting fossil animals, osteology has become one of the most important bases of comparative anatomy and geology. By the study of bones the anatomist has been enabled to determine genera and species, no longer existing on the face of the globe, and to give as it were new life to these old and disjointed relics of the antediluvian animal kingdom. Thus the fossil bones, deposited in an invariable order of superposition in the crust of the earth, have been transformed into monuments more authentic than historical records.

General view of the skeleton. The bones form a system or whole, of which the different parts are contiguous, and united to each other. The only exception to this rule is the *os hyoides*, and yet the ligaments by which it is connected with the rest of the system are evidently the representatives of the osseous pieces, which in the lower animals connect this bone with the temporal.

The assemblage of the bones constitutes the *skeleton.* It is called a *natural skeleton*, when its different parts are connected by their own ligaments; an *artificial skeleton*, on the other hand, is one of which the bones are joined together by artificial connexions, such as metallic wires, &c.

The result of this union is a symmetrical and regular structure, essentially composed of a central column, denominated the *vertebral column or spine*, which terminates superiorly in a considerable enlargement — the *cranium*, and inferiorly in certain immovably united vertebræ which constitute the *sacrum and coccyx.* To this column the following appendages are attached: 1. In front of and below the cranium a complicated osseous structure, the *face*, divided into two maxillæ, the *superior* and *inferior.* 2. On each side twelve bony arches, flexible, elastic, and curved — the *ribs*, which are united in front to another column, the *sternum.* These parts taken together form the thorax. 3. Four prolongations, called *limbs* or *extremities*, two superior, or *thoracic* as they are termed, because they correspond with the chest or thorax, and two inferior or *pelvic*, so named on account of their connexion with the basin or *pelvis*, but better named *abdominal extremities.* The thoracic and abdominal extremities are evidently modifications of the same fundamental type, and are essentially composed of the same number of analogous parts, viz. 1. An osseous girdle, the superior constituted by the bones of the shoulder, the inferior by the pelvis. 2. A part which may be in some measure regarded as the body of the limb, viz. the *humerus*, in the thoracic extremity, the *femur* in the abdominal. 3. A manubrium or handle, to use an expression of Galen, above the *forearm*, below the *leg.* 4. Lastly, digitated appendages which form the extremities, properly so called, viz. the *hand* and the *foot.*

Number of the bones. Authors do not agree respecting the number of the bones. Some for instance describe the sphenoid and the occipital as forming only one bone, while most anatomists consider them two distinct bones. Some admit three pieces in the sternum, which they describe separately. Many, after the example of the older writers, divide the haunch into three distinct bones — the pubes, the ischium, and the ileum: others recognise five pelvic, or sacral vertebræ; three or five parts of the os hyoides: and lastly, the ossa sesamoidea and the ossa wormiana are omitted by some, but by others are reckoned in the enumeration of the bones.

The ideas of certain modern authors with respect to the development of the bones, instead of dispelling the uncertainty which attaches to the enumeration

of the parts of the skeleton, have tended not a little to increase the confusion, because many of them have made no distinction between bones, properly so called, and pieces of ossification. All doubt, however, in this respect will cease, provided we consider as distinct bones only those portions of the skeleton, which are separable at the time of complete development.

The time at which the osseous system arrives at its perfect development, is between the twenty-fifth and thirtieth year.

According to these views, we may count in the human body 198 bones, viz.

Vertebral column including the *sacrum* and *coccyx* - -	26
Cranium - - - - -	8
Face - - - - - -	14
Os hyoides - - - - -	1
Thorax (ribs, sternum) - - - -	25
Superior extremities, each 32, viz. shoulder, arm, forearm, and hand	64
Inferior extremities, each 30, viz. pelvis, thigh, leg, and foot -	60
	198

This enumeration does not include the ossa wormiana, nor the ossa sesamoidea, among which we include the patella.

Of these 198 bones, 34 only are single: all the others are in pairs; which reduces the number to be studied to 116.

Before proceeding to examine each piece of the skeleton in particular we shall state the method we intend to pursue in the description. The chief points embraced by detailed descriptions of a bone are, 1. Its name; 2. Its general situation; 3. Its direction; 4. Its bulk and weight; 5. Its figure; 6. Its regions; 7. Its internal conformation; 8. Its intimate texture; 9. Its development.

Nomenclature. Osteological nomenclature has many imperfections. Persuaded of the importance of a suitable choice of language in the study of all the sciences, some anatomists have endeavoured to introduce reforms, but with little success, the old denominations being still for the most part retained. From these modern systems of nomenclature we shall adopt only such terms as are strikingly appropriate, or such as have already been sanctioned by usage. We may here observe that the denominations of bones have been derived, 1. from their situation; as the *frontal*, which is so called because it is situated in the forehead; 2. from a resemblance, usually very obscure, to some well-known object, as the bones named *tibia*, *scaphoid*, *malleus*, *incus*, *stapes*; or to some geometrical figure, as the *cuboid*; 3. from their size; as the *os magnum* of the carpus, and the small bones or *ossicula* of the ear; 4. from some circumstance of their external conformation; as the *cribriform* or *ethmoid* bone, the *unciform* or hooked bone; 5. from the name of the author who first most carefully described them; as the ossicles of *Bertin*, of *Morgagni*—wings of *Ingrassias*, &c.

General situation of bones. The situation of a bone is determined by comparing the place which it occupies with that occupied by other bones of the skeleton. In order to make this comparison, the skeleton is supposed to be surrounded by certain planes, which are thus denominated:—1. *An anterior plane*, passing before the forehead, the breast, and the feet:—2. *A posterior plane*, passing behind the occiput and the heels:—3. *A superior plane*, placed horizontally above the head:—4. *An inferior plane*, which passes below the soles of the feet:—5. and 6. *The two lateral planes*, which complete the sort of case or parallelopiped with which we suppose the skeleton to be surrounded. Lastly, the skeleton being symmetrical, i. e. exactly divisible into two similar halves, we admit a seventh imaginary plane, the median or antero-posterior, separating these two halves. By the term median line is understood an imaginary line traced so as to mark exteriorly the division of all the symmetrical bones of the skeleton into two similar halves.

These points being understood, nothing is more easy than to determine the

position of a bone. If it approach nearer to the anterior plane than others with which it is compared, it is said to be anterior to them; if it be nearer the posterior plane, it is said to be posterior to them. Let us take for example the malar or cheek bones. With respect to the whole face, they are placed at the anterior, superior, and in some degree the lateral part: relatively to the neighbouring bones they are situated:—1. below the frontal:—2. above and a little external to the maxillary:—3. before the great wings of the sphenoid and the zygomatic process of the temporal.

Direction of bones. The direction of a bone is *absolute* or *relative.* The absolute direction is expressed by the terms *straight, curved, angular,* or *twisted,* in a word it is the direction of a bone considered by itself, or independently of its situation in the skeleton. The long bones are never quite straight: sometimes they present a slight degree of curvature, as the femur; sometimes their extremities are curved in opposite directions, like the letter S, as the clavicle: sometimes again they are twisted upon their own axes, as the humerus, the fibula, &c.

The *relative* direction is determined by reference to the planes which circumscribe the skeleton. Viewed in this manner, a bone is *vertical, horizontal,* or *oblique.* It is needless to enter into any explanation of the terms vertical and horizontal; but with regard to the oblique direction, it may be stated that this is determined by the respective situations of its two extremities. For example, a bone is oblique, when one extremity approximates the superior, the median, and the posterior planes, while the other approaches nearer to the inferior, lateral, and anterior planes: such a bone is said to be oblique, from *above downwards,* from *within outwards,* and from *behind forwards.* It is easy to see that in this way the situation of a bone relatively to the different planes, may be determined with the greatest exactness. It should be observed, that in describing the direction of a bone, we should always set out from the same point. Thus if the direction of a bone from above downwards is spoken of, in determining its obliquity from before backwards, and from within outwards, we should always commence with the superior extremity.

Size, weight, and density of bones. The size of a bone may be measured by the extent of its three dimensions; but as an exact estimate is not in general required, it is sufficient to indicate the volume of each bone relatively to others, whence has arisen the division of bones into *great, middle-sized,* and *small;* a distinction, however, altogether vague and futile, since from the largest to the smallest bones there is so regular a gradation that the limits assigned must be quite arbitrary.

The *weight* or the mass of the skeleton compared with the rest of the body, the weight of each bone, and the comparative weight of different bones, are points of little interest; such however is not the case with the specific weight or density of bones.

In respect of *density,* viz. the number of molecules in a given volume, the bones are the heaviest of all organs. The truth of this assertion is by no means contradicted by the lightness of certain bones, which is only apparent, and which is caused by vacant spaces or cells in their substance. This density varies in different kinds of bones, in bones of the same kind, and even in different parts of the same bone. Thus, in the long bones, the greatest density is in the middle: the extremities of the long bones and the short bones have a much lower density. The broad or flat bones hold a middle place between the shaft of long bones and the short bones. Of these broad bones those of the cranium are heavier than those of the pelvis. Age has a remarkable influence upon the specific weight of bones. It has been said that the bones of the aged are specifically more heavy than those of the adult, just as the bones of the adult are specifically heavier than those of the infant: and this assertion appears the more probable, from it being generally admitted, as a law of organisation, that the phosphate of lime increases in bones, with the progress of age; and it is well-known that the weight of bones depends in part on the

presence of this calcareous phosphate. But on this point, as on many others, experience has refuted these preconceived opinions. Thus, it is certain that the specific, as well as the absolute weight of bones, is much less considerable in the old person than in the adult: and this difference depends upon the loss of substance which the bones undergo, in common with all other tissues, during the progress of age: thus, in aged subjects, the walls of the cylinder of the long bones are remarkably diminished in thickness, while the medullary cavity is proportionally increased. We may even affirm with Chaussier, that the medullary cavity of the shaft of long bones has a greater diameter, in proportion as the individual is advanced in age. In like manner the cells of the spongy tissue become much larger, and their walls acquire an extreme tenuity. It may nevertheless be contended, that the weight of the osseous fibre, or rather of the osseous molecules of the old people, is greater comparatively than that of the same parts in the adult: and this presumption is almost converted into certainty by chemical analysis, which shows an excess of phosphate of lime in the bones of the aged: to remove all doubts upon this point, it would be necessary to grind an adult bone and an old one, and to weigh in the balance an equal bulk of each powder. In this way the contradictory statements of certain authors might be reconciled.

The increasing fragility of bones and the consequent frequency of fractures in old age is easily explained, since along with the accumulation of phosphate of lime, which diminishes the elasticity while it increases the brittleness, there occurs a diminution of bulk, and consequently there is less resistance. It is with respect to the quantity of calcareous phosphate alone, that the osseous system can be said to preponderate in old age.

Shape of bones. The shape of a bone is determined, 1. by comparison either with different known objects, or with geometrical figures: thus the frontal bone has been compared to the scallop-shells of pilgrims, the sphenoid to a bat with extended wings, &c. It may be readily conceived that notwithstanding its want of exactness, this method of comparison, so familiar to the ancients, cannot be altogether proscribed. The comparison of bones whose forms are so irregular with the regular solid figures of which geometry treats, is no less inaccurate than the preceding; nevertheless, we shall continue, like other anatomists, to speak of the short bones as *cuboidal*, the shafts of long bones as being *prismatic* and *triangular*, the lower maxillæ *parabolic*, &c. We shall speak of spheres, of cones, of ovoids, of cylinders, &c.

2. The symmetry or want of symmetry of bones is a fundamental point in the determination of their figure: thus some bones are divisible into two halves exactly resembling each other; these are the symmetrical or *azygos* bones, also called median, because they always occupy the middle line. The others cannot be divided into two similar parts: these are the asymmetrical bones, called also *lateral* or *corresponding*, because they are always in pairs, and situated on opposite sides of the median line.

3. The figure of a bone comprehends also the proportion which its three dimensions bear to each other. When the three dimensions, length, breadth, and thickness, are nearly equal, the bone is said to be *short;* when the length and breadth are almost the same, and both greater than the thickness, the bone is called *broad* or *flat*. Lastly, the predominance of one dimension over the two others constitutes the character of *long* bones. The distinction here drawn, however, is not altogether exact, because there are certain mixed bones which partake at the same time of the character of the long and the broad bones.

Some general observations upon the three great classes will not be out of place here, as they will be applicable in the description of the individual bones.

General Characters of long, flat, and short Bones.

Of long bones. The long bones are situated in the extremities, in the centre of which they form a set of pillars or levers placed upon each other. The bones of the abdominal extremities are generally longer and larger than

those of the thoracic. The longest bones are in the upper part of the limbs; it may be said indeed that the length of bones is in the direct ratio of their proximity to the trunk. The diameter of the long bones is smallest in their middle. From this part, as from a centre, they gradually increase in volume, and at their extremities are much enlarged, so as to present a diameter double or treble that of the shaft. Every long bone, therefore, presents a *biconical* form, *i. e.* is shaped like two cones united by their summits.

A long bone consists of a *shaft* and *extremities*. The *shaft* of the long bones is almost always prismatic and triangular; so much so, that in this respect the bones seem to be an exception to the general rule of organised bodies, which have usually a rounded form, and to approach nearer that of the mineral kingdom, the characteristic shape of which is angular.

The *extremities* of long bones are enlarged, that they may serve, 1. for articulations; 2. for the insertion of ligaments and muscles; 3. for the reflection of tendons, the direction of which they alter. Each extremity presents a smooth articular surface, covered with cartilage in the fresh state, and not perforated by any foramina, and a non-articular portion, rough, pierced with apertures, and covered with eminences and depressions.

Of broad or flat bones. These bones, intended to form the parietes of cavities, are more or less curved, and present, for consideration, a circumference and two surfaces; the internal concave, the external convex. No single broad bone constitutes a cavity; there are always a certain number united for this purpose. Some broad bones are alternately concave and convex on the same surface, as the haunch bones. In flat or broad bones there is no accurate correspondence between the inequalities, ridges, or depressions of the two surfaces. Thus the iliac portion of the haunch bones, instead of presenting a convexity on the inner surface, to correspond with the external iliac fossa, is hollowed out into another depression, the internal iliac fossa. In like manner, in the cranium certain impressions and eminences exist on the internal surface, while the external is uniformly convex and almost smooth. The parietal, and even the occipital protuberances, would be twice or three times more prominent if the interior concavity were faithfully represented by a corresponding external prominence, and if this concavity were not in a great measure hollowed out from the substance of the bone.

The *circumference* of broad bones being intended either for articulations, or for insertions, is for this purpose greatly thickened. Thus the parietal bones, which are very thin at their centre, become considerably thicker at the circumference. The broad bones present at their circumference sometimes a simple enlargement, when it is intended for muscular insertions only; for example, the haunch bones: sometimes indentations of various kinds, and sinuosities, when it is to serve the purpose of articulation; for instance, the bones of the cranium.

Of short bones. These are principally met with in the vertebral column, the carpus, and the tarsus; in fact, wherever great solidity is required in connexion with slight mobility: several of them are always grouped together; their form is extremely irregular, but generally cuboid; they have also numerous facettes for articulation. The non-articular portion is rough for the insertion of ligaments and tendons.

Regions of bones. There are so many objects to be considered on the surface of a bone, that it is necessary, in order to prevent the omission of any essential detail in the description, to divide the surface into a certain number of parts or regions, which should be successively examined. These different parts or regions have been denominated *faces*, *borders*, and *angles*. Thus in the prismatic and triangular shafts of long bones, there are *three faces* and *three borders* to be considered; in the flat bones *two faces* and *a circumference*, which is again subdivided into *borders* and *angles* formed by the meeting of these borders. There are *six faces* in the short bones. These faces and borders are named sometimes from their *situation superior, inferior, anterior*, posterior, &c.;

sometimes from the parts which they contribute to form, such as the *orbital* and *palatine* faces of the superior maxillary bone; sometimes from their relations to other parts, as the *cerebral* and *cutaneous* face of the bones of the cranium, the *frontal*, *occipital*, and *temporal* borders of the parietal bones. When the borders give insertion to a great number of muscles, it has been deemed advisable to divide these into three parts or parallel lines: the middle is then called the *interstice*, and the two lateral are named *lips*, the *internal* and *external* lip; the superior border of the haunch bone, and the linea aspera of the femur are examples.

Eminences and cavities of bones. The bones present certain eminences and cavities, of which it is proper to take a general survey in this place.

Eminences of bones. The osseous eminences or processes were divided by the ancients into two great classes, *apophyses* and *epiphyses*, distinguished by the difference of their mode of development. According to their view, some of these eminences arise from the body of the bone, appearing to be nothing more than prolongations or vegetations of its substance: these they called *apophyses;* others, on the contrary, are formed by separate osseous centres or nuclei, which make their appearance at various times during the process of the development of bone: to these they gave the name of *epiphyses.* This distinction, however, founded upon incomplete observation, has been totally rejected, since the researches of M. Serres on Osteogeny have rendered it evident, that almost all the osseous eminences are developed from isolated nodules; so that an eminence, which at one time is an epiphysis, becomes afterwards an apophysis. If therefore the majority of eminences are formed from separate osseous points, the difference between them can apply only to the relative periods at which they become united to the body of the bone.

A far more important distinction is that by which the eminences are divided into *articular* and *non-articular.*

The *articular eminences* have received different names. 1. They are called *denticulations*, when they form angular eminences resembling the teeth of a saw; these are best seen in the bones of the cranium. This kind of eminence is employed only in immoveable articulations.

The others belong to joints which admit of motion, and have received the following names: 1. They are called *heads* when they represent a portion of a sphere supported by a more contracted portion to which the name of *neck* is given; for example, the head and neck of the femur. 2. The term *condyle* is applied to them when they resemble an elongated head, or a portion of an ovoid cut parallel to its greatest diameter; for example, the condyles of the inferior maxilla.

The *non-articular eminences* are for the most part designed for muscular insertions. Their appellations are in general derived from their shape. Thus they are denominated:—

1. *Prominences.* When they are but slightly elevated, smooth, and almost equally extended in all directions; as the parietal and frontal eminences.

2. *Mamillary processes.* When they resemble papillæ; for instance, the mamillary processes of the internal surface of the bones of the cranium.

3. *Tuberosities.* When they are of a larger size, round, but uneven; for example, the occipital protuberance, the bicipital tuberosity (or tubercle) of the radius.

4. *Spines* or *spinous processes.* When from their acuminated, but generally rugged form they bear some resemblance to a thorn; as the spine of the tibia, the spinous processes of the vertebræ.

5. *Lines.* When their length greatly exceeds their breadth; as the semicircular lines of the occipital bone. When these lines are more prominent and covered with asperities, they receive the name of lineæ asperæ; as the linea aspera of the femur.

6. *Crests.* When they are elevated, and have a sharp edge; as the external and internal crest of the occipital bone, the crest of the tibia. One of these

eminences has been denominated the *crista galli*, because it bears some resemblance to the comb of a cock.

7. The term *apophyses* (*or processes*) has been retained for those eminences which are of a certain size, and appear to form as it were a little bone superadded to that from which they spring; they are distinguished for the most part by epithets derived from their shape. Thus, the *clinoid processes* of the sphenoid are so called from their supposed resemblance to the supporters of a bed (κλίνη, a bed; εἶδος, shape). *Pterygoid* processes are those which are like wings (πτέρυξ, a wing). *Mastoid*, such as resemble a nipple (μαστὸς, mamma). *Zygomatic*, such as have the form of a yoke (ζυγὸς, a yoke). *Styloid*, such as are like a style. *Coronoid*, such as are shaped like one of the angular projections of a diadem.* *Odontoid*, such as resemble a tooth; as the odontoid process of the second cervical vertebra. *Coracoid*, such as have the form of a raven's beak (κόραξ, a raven); as the *coracoid* process of the scapula. *Malleoli*, such as are like a hammer (malleus, a hammer).

Some processes have received names: 1. from the parts they contribute to form — orbitar processes, malar processes, olecranon (ὠλένη, the elbow; κράνον, head): 2. from their direction; as the *ascending* process of the superior maxilla: 3. from their uses; as the trochanters (τροχάω, to turn), because they serve for the insertion of muscles, which rotate the leg on its own axis.

No part of the language of osteology perhaps is more faulty than the nomenclature of the eminences. Thus, how unlike is the spine of the scapula to the spinous processes of the vertebræ, or the styloid process of the temporal to the diminutive projection called styloid of the radius! Many eminences which perform analogous offices have received different names: thus the eminences of the humerus, which give attachment to its rotating muscles, are called the great and small tuberosities; while the corresponding parts of the femur have been denominated trochanters. Whilst therefore we retain the names consecrated by usage, we shall be careful to point out the more rational terms substituted by modern anatomists, and particularly by Chaussier.

The size of the eminences of insertion is in general proportional to the number and strength of the muscles and ligaments which are attached to them. To be convinced of this fact, it is only necessary to compare the male and female skeleton, or that of a man of sedentary habits and that of a person devoted to athletic exercises. This remarkable correspondence between the size of osseous eminences and the strength of the muscles which are inserted into them, has given rise to the opinion that these eminences are formed by muscular traction. It is easy to refute this notion, and without entering into details which belong to general anatomy, we shall prove, by facts, that the osseous projections enter into the primordial plan of organisation, so much so, that they would have doubtless existed, even though the muscles had never exercised any traction upon the bones. I have twice had occasion to dissect the thoracic extremities of individuals, who in consequence of convulsions during their earliest infancy had suffered complete paralysis of these parts. The limb affected had scarcely the proportions of that of a child of eight or nine years, whilst the opposite limb was perfectly developed. Nevertheless in this atrophied limb the smallest, as well as the largest projections were perfectly marked. Moreover, very powerful muscles are often inserted into cavities, as, for instance, the pterygoid cavity of the sphenoid.

Cavities of bones. Besides the great cavities of the skeleton, cavities in the formation of which many bones concur, and which are destined to lodge and defend the organs most important to life, there are a great number of smaller excavations formed in the substance of the bone itself.

These cavities, like the eminences, are divided into two great classes, *articular* and *non-articular*. The *articular cavities* have received different names. 1. The term *cotyloid* designates the articular cavity in the haunch bone, be-

* [Also from κορώνη, a crow — like a crow's beak.]

cause it is deep and round, like a vessel known by the ancients under the name of κοτύλη. 2. The name *glenoid* (from γλήνη) is applied to many articular cavities, which are more shallow; for example, the glenoid cavity of the scapula, the glenoid cavity of the temporal bone. 3. The term *alveoli* has been assigned to the cells or sockets in which the roots of the teeth are lodged. It is not correct, however, to consider as an articulation the union of the teeth with the jaws, because, as we shall afterwards show, the teeth are not true bones.

The *non-articular cavities* are to be considered with reference both to their figure, and their uses. From their figure they have received the following denominations: 1. *Fossæ*, or pits, are cavities largely excavated, wider at the margin than at the bottom; ex. the parietal fossæ. 2. *Sinuses* are cavities with a narrow entrance; as the sphenoidal sinus, maxillary sinus, &c. 3. The term *cells* is applied when the cavities are small but numerous, and communicating with each other, as the ethmoidal cells, &c. 4. *Channels* (*gutters*) are cavities which resemble an open semi-cylindrical canal; as the channels for the longitudinal and lateral sinuses of the skull. 5. These take the name of grooves (*coulisses*) when they are lined by a thin layer of cartilage, for the passage of tendons; as the bicipital groove of the humerus. The term *pulley* or *trochlea* is applied to grooves, which have their two borders also covered with cartilage. 6. *Furrows* are superficial impressions, long but very narrow, and intended for the lodgment of vessels or nerves, as the furrows for the middle meningeal artery. 7. When more deeply excavated than the last, and angular at the bottom, they are named by the French anatomists *Rainures*. 8. *A notch* (*incisura*) is a cavity cut in the edge of a bone.*

The cavities which we have described exist only on one surface of a bone; those which perforate its substance are usually denominated *foramina* or *holes*.

1. When a foramen has an irregular, and, as it were, lacerated orifice, it is named a *foramen lacerum*. 2. When its orifice is very small and irregular, it is called *hiatus*; when the opening is long, narrow, and resembling a crack or slit, it is denominated a fissure; as the sphenoidal fissure, the glenoid fissure, &c. 3. If the perforation runs some way through the substance of a bone it is called a *conduit* or *canal*, as the Vidian canal, carotid canal, &c.

There are some canals which lodge the vessels intended for the nourishment of the bone: these are called *nutritious canals*. They are divided into three kinds.

The first which belong exclusively to the shafts of long bones, and to some broad bones, penetrate the substance of the bone very obliquely. These are the *nutritious canals, properly so called*. Anatomists carefully point out their situation, size, and direction, in describing each bone.

The second kind are seen on the extremities of long bones, on the borders or adjoining the borders of broad bones. Canals of this kind are generally near the articular surfaces. Their number is always considerable. Bichat has counted 140 on the lower end of the thigh bone, twenty upon a vertebra, and fifty upon the os calcis.

The third kind of nutritious canals are exceedingly small, and might be denominated the *capillary canals of bones*. They are found in great numbers on the surface of all bones. They may be easily seen by aid of a good magnifying glass; their presence is also indicated by the drops of blood which appear upon the surface of a bone on tearing off the periosteum; for example, on the internal surface of the cranium after separating the dura mater. The diameter of these little canals has been calculated to be about the $\frac{1}{20}$ of a line

The further progress of the above-mentioned canals is as follows: those of the first kind which belong to the long bones, soon divide into two secondary canals, one ascending, the other descending, and communicating with the central or medullary cavity. Those which are situated in the broad bones form winding passages, which run for a considerable distance in the substance of the bone.

* [*There is great latitude among anatomical writers in the use of these terms.*]

The canals of the second kind sometimes pass completely through the bone (as in the bodies of the vertebræ), and they communicate with the spongy tissue. The canals of the third kind terminate at a greater or less depth, in the compact substance of the long bones, and in the spongy tissue of the short bones. Such are the forms and general arrangement of all the cavities which exist on the surface of a bone: the following are their uses: 1. They serve for the reception and protection of certain organs; ex. the occipital fossæ, which receive a portion of the cerebellum. 2. For insertion or surfaces of attachment, as those on which muscular fibres are implanted, as the temporal and pterygoid fossæ. 3. For the transmission of certain organs, such as vessels and nerves which have to pass into or out of an osseous cavity; such are the fissures, canals, foramina, &c. 4. For increasing the extent of surface; as the sinuses and cells, connected with the organ of smelling, the surface of which they greatly enlarge by their numerous anfractuosities.* 5. For the easy passage of tendons and sometimes for their reflection, so that the original direction of the force is changed. To this class belong the bicipital groove of the humerus, that for the tendon of the obturator internus, &c. They are generally converted into canals by means of fibrous tissue, which lines and completes them. 6. For the nutrition of bones, such being the use of the three orders of nutritious canals already described. We must mention along with these osseous cavities other markings or impressions seen on the surface of many bones; for example, the shallow depressions in the lower jaw bone for the sublingual and sub-maxillary glands, the impressions named digital on the internal surface of the cranium.

As the eminences of bones have been attributed to the mechanical effect of muscular traction, so the various impressions and vascular furrows upon the internal surface of the cranium have been considered to be the result of pressure and pulsation. But it would be more correct to limit ourselves to the simple statement, that the impressions and eminences on the inside of the cranial bones exactly correspond with the elevations and depressions on the surface of the brain, and also that the osseous furrows for the middle meningeal artery correctly represent the ramifications of that vessel.

We may here point out certain rules to be followed in describing the external conformation of bones. 1. In describing the surface of a bone it should be so divided, that the description may comprehend but few objects at a time. Thus a broad bone is to be divided into two surfaces, into angles and borders, which are to be successively studied. 2. The bone being thus subdivided into regions, each of these is then examined, care being taken regularly to proceed from one part to its opposite, *i. e.* to pass from the superior to the inferior surface, and from the anterior to the posterior. This is the only method which in a long description will guard against omissions and avoid tiresome repetitions. 3. It is also of great importance, in considering the objects presented by each region or surface, to follow an invariable and regularly progressive order. Thus, after exposing the objects placed in front, the examination should be continued uninterruptedly from this point backwards. 4. In the symmetrical bones, it is advisable to describe, first, the objects situated in the median line, and afterwards those placed laterally.

Internal conformation of bones. The tissue of bones, like that of most other organs, presents the appearance of fibres, whose properties are throughout identical, but which by certain differences in their mode of arrangement give rise to two forms or modifications of structure. To one of these the name of *compact substance* has been given; to the other that of *spongy or cancellated substance.* A subordinate modification of the latter has long been described under the name of *reticular tissue.*

The spongy or cellular substance has the appearance of cells and areolæ, of

* [Whatever other purpose they may serve, such cells and sinuses are, in most instances, to be regarded as a provision for increasing the bulk and strength of bones without a corresponding augmentation of weight.]

an irregular shape and variable size, all of which communicate with each other, and their walls are partly fibrous, partly lamellar. The compact substance seems to consist of fibres strongly compressed, so as to form a close firm tissue. It is both fibrous and areolar. By means of careful inspection, softening the bone in nitric acid and studying its development, it has been clearly proved that it is *fibrous* and that in long bones the fibres are arranged longitudinally, while in broad bones they seem to diverge like rays from the centre to every part of the circumference; and that in the short bones they are disposed irregularly, so as to form a superficial layer, or crust. The researches of Malpighi have conclusively shown that it is also *areolar*, or *spongy*. By examining a bone softened by nitric acid or studying it in the fœtal state, it may be seen that in fact the compact tissue is nothing more than an areolar substance, the meshes of which are extremely close, and much elongated. Accidental ossifications, and the diseases of bone which so frequently exhibit the compact tissue converted into spongy, and the spongy changed into compact, complete the demonstration.*

In strictness, therefore, but one form of osseous tissue can be admitted, namely, the areolar, which presents itself under two aspects, sometimes being close, compact, and fasciculated, sometimes spongy and cellular. Having thus become acquainted with these two forms of osseous tissue, their general arrangement in the different kinds of bones is next to be examined.

Internal structure of long bones. A vertical section of a long bone presents in the body or shaft a cylindrical cavity, which, in the fresh state, is filled with a soft fatty substance, named the *marrow*. This cavity, or *medullary canal*, is of greatest diameter at the middle of the shaft; and as it recedes from this point, it is narrowed and intersected at various parts by lamellæ detached from the sides, and forming a sort of incomplete partitions. Sometimes, however, there is a complete partition: thus I have seen the cylinder of a femur divided into two distinct halves by a horizontal partition situated precisely in the middle of the bone. The medullary canal is not regularly cylindrical, nor does it correspond in figure with the external surface of the bone. It communicates with the exterior by means of the nutritious canals, which sometimes run for a considerable distance in the substance of the bone, parallel to the medullary cavity, with which they communicate by numerous apertures, and transmit the vessels as far as the extremities of the bone. Some have supposed that the cavity existed only in order to receive the marrow, while on the other hand it has been maintained, that the marrow existed only to fill up the cavity. Whatever be the uses of the marrow, it is certain that the existence of a cavity in the centre of long bones is an advantageous provision for strength; for it is proved in physics, that of two cylinders composed of the same material in equal quantity, the one which is hollow, and whose diameters are consequently greater, will offer greater resistance than that which is solid. By the contrivance, therefore, of the medullary canal there is an increase of strength without augmentation of weight. There is another advantage in this arrangement, viz. the increase of volume without corresponding increase of weight. For since the bones are intended to give insertion to numerous muscles, it is necessary that their surfaces should not be reduced to too small dimensions, but this must have been the result had the walls of the hollow cylinder been compressed so as to form a solid rod. The marrow consists of

* [The description in the text applies to the more obvious structure of bone; but when examined with the microscope, the osseous substance, both compact and spongy, is seen to consist of exceedingly fine lamellæ laid on one another. In the compact external crust of bones these lamellæ run parallel with the surface; they also surround concentrically the small cavities of the compact substance and the cells of the spongy texture, the parietes of which they form. They are not to be confounded with the coarser layers and plates described in the compact substance by Gagliardi, Monro, and others of the older writers. Along with the lamellæ there are minute, opaque, white bodies, with extremely fine lines irregularly branching out from them. These bodies, which can be seen only with the aid of the microscope, are named the osseous corpuscules; they obviously contain calcareous matter, and are probably minute ramified cavities lined with earthy salts. The earthy matter of bone, however, is not confined to the corpuscules, for the intermediate substance is also impregnated with it. For a representation of the minute structure of bone, see *Muller's Physiology*, translated by Baly, Plate I.]

two distinct parts :— 1. The medullary membrane which lines the walls of the canal; 2. The fatty tissue, properly so called, or the medullary liquid.

The membrane, highly vascular, serves to nourish the internal layers of the bone: it possesses great sensibility and a high degree of vitality. The fatty tissue, on the contrary, is altogether insensible. If a probe be introduced into the centre of the medulla of a long bone in a living animal, no sign of pain is evinced *so long as the instrument does not touch the walls of the cavity*; but whenever the walls are rubbed or scratched, the pain becomes excessive, and is manifested by piercing cries and violent struggles.

The proportion between the thickness of the walls of the cylinder, and the diameter of the medullary canal, varies not only in different individuals, but in the same person at different periods of life. In the aged, the thickness of the walls is proportionally much less than in the adult: this is one cause of the great fragility of the bones in old age. Sometimes in the adult the walls are so thin, that the bone breaks by the slightest force: in such cases there is in some sort hypertrophy of the medulla and atrophy of the bone. It is in such cases that fractures occur from the simple effect of muscular contraction, or even from moving in bed.

It is in the central canal of long bones that those very delicate osseous filaments are observed, which, interlacing with each other, and forming large meshes, give rise to that variety of spongy tissue which has received the name of *reticular*, and which appears intended to give support to the medulla. The compact tissue diminishes, and the cells increase in number, the greater the distance from the centre of the bone, so that the extremities are entirely composed of spongy substance covered by a thin layer of compact tissue. It appears that the compact tissue which forms the shafts of the bones, divides and subdivides into lamellæ, in order to form the cells of the extremities. It is easy to perceive the advantage of a spongy structure in the usually voluminous extremities of the long bones: they could not have been compact without a great increase of weight, while the additional strength thus acquired would have been redundant and altogether useless.

The cells of the spongy substance are filled by an adipose tissue, similar to that which exists in the bodies of long bones: from its greater fluidity it has been denominated *medullary juice*.

Internal structure of broad bones. If the surface of a broad bone be scraped, or if the bone be sawn across perpendicularly or obliquely, it will be found to consist of two *lamellæ* or *tables*, separated by a greater or less thickness of spongy tissue. Hence the two plates are insulated, and one may be fissured or broken without injury to the other. The thickness of the compact laminæ and of the spongy tissue is not uniform throughout the whole extent of a broad bone. At the centre, for example, there is scarcely any spongy tissue, and hence the transparency of the bone at this part. Towards the circumference, on the contrary, the spongy tissue forms a very thick layer.

In the bones which form the vault of the cranium, the spongy substance takes the name of *diploë* (διπλόος, double), because it occupies the interval between the two tables.

From what has been said regarding the internal structure of broad bones, it is evident that their distinctive character depends as much upon their internal as their external conformation, and therefore the ribs, which according to their external characters seem rather to belong to the long bones, have been classed among the broad, because they exhibit in their internal structure the characters of the latter kind of bones.

Internal structure of short bones. The extremity of a long bone, if separated from the shaft, would represent a short bone, both in its external and internal conformation; for a short bone is a spongy mass, covered by a thin layer of compact tissue. To their spongy structure the short bones, as well as the extremities of the long, owe their specific lightness.

It should be observed, that what has been said concerning the internal struc-

ture of bones applies in strictness only to those of the adult, because the younger the subject, the less are the cells of the spongy tissue developed. And in like manner as the walls of the cylinder of long bones diminish in thickness, and the medullary cavity increases in diameter in the aged, so by the progress of age the walls of the cells become extremely thin, and the cells themselves very large. In some cases of disease, for example after white swelling of the ankle-joint, I have observed true medullary canals in the cuboid bone and calcaneum; and I have remarked in one case of cancer of the breast, that the ribs adjoining the tumour were hollowed out by a sort of medullary canal. It is to this diminution of the osseous substance, this kind of atrophy of the bone, that I am disposed to attribute the fragility so often observed in the whole osseous system in cancerous diseases.

Chemical composition of bones. The bony tissue consists essentially of two distinct elements, one *inorganic*, the other *organised.* When a bone is subjected to the action of dilute nitric acid, the salts are removed, it becomes flexible and elastic like cartilage, and though retaining its original bulk and form, it is found to have lost a great part of its weight. By this process its saline ingredients have been dissolved, and nothing remains but its organic constituents, which being subjected to boiling, present all the characters of gelatine.

On the other hand, if a bone be calcined, the whole of its organic matter is destroyed, giving out during the process the odour of burned horn. A substance remains which preserves exactly the shape and size of the original bone, but at the same time is very light, porous, and so friable, that it crumbles to powder under the slightest pressure. If the calcination be complete, the bone is rendered perfectly white, but it is black when the burning has not been carried sufficiently far; it may even be vitrified by a more intense heat applied for a longer time. Prolonged exposure to the action of air and moisture in like manner remove the organised substance, and leave only a calcareous residue. The two elements of bone do not bear the same proportion at different ages. Certain diseases greatly affect the predominance of one or the other, producing almost the same effects as chemical agents.

To the inorganic matter the bones owe their hardness and durability; to the organised substance they are indebted for their vitality and the slight degree of flexibility and elasticity which they possess.

The following are the results furnished by the chemical analysis of M. Berzelius:—

1. Organised part	1. Animal matter reducible to gelatine by boiling	32·17
	2. Insoluble animal matter	1·13
2. Inorganic part	Phosphate of lime	51·04
	Carbonate of lime	11·30
	Fluate of lime	2·0
	Phosphate of magnesia	1·16
	Soda and chloride of sodium	1·20

The bones are furnished with vessels: by one set arterial blood is transmitted, by another venous blood is returned.

1. The *arteries* are of three orders, corresponding with the osseous canals which have been described in speaking of the cavities of bones.

First order, or *arteries of the medullary canal of long bones.* In each medullary canal there is at least one principal artery which enters by the nutritious canal and divides almost immediately into two branches, one ascending, the other descending. These subdivide into an infinite number of small branches, the interlacements of which form that vascular network called the medullary membrane. With this network the vessels of the second order freely anastomose after their entrance at the extremities of the bone. In consequence of this important communication, the vessels, notwithstanding the great difference in the manner of their entering the bone, can reciprocally supply each other with blood In illustration of this, Bichat relates a singular case, in which the nutritious foramen of a tibia was completely obliterated, and yet the nutrition

of the bone was unimpaired. The medullary artery gives off the twigs for those layers of compact tissue which form the parietes of the medullary cavity.

The arteries of the second order, destined for the spongy tissue, enter the bones by the nutritious foramina of the second order; but their number by no means corresponds with that of the foramina, which are for the most part destined for the transmission of veins. These arteries communicate both with the medullary artery already mentioned and with the arteries of the periosteum.

The arteries of the third order, or the *periosteal arteries*, are exceedingly numerous. This class comprehends the innumerable little arteries which, after ramifying in the periosteum, enter the bone by the minute canals of the third order. These small vessels specially distributed to the exterior layers of compact substance, anastomose with the two preceding orders of vessels.

2. The *veins* of bones follow the course of the arteries. But there are peculiar venous canals in the interior of the broad and the short bones, and in the spongy extremities of the long bones. These canals were first described by M. Dupuytren in the cranial bones, where they are very obvious: they are perforated with lateral openings, by which they receive blood from the adjoining parts; their parietes are formed by a very thin plate of compact tissue, and they are lined by a prolongation of the internal membrane of the veins. We shall afterwards see that there is a complete analogy between these venous canals and the sinuses of the dura mater, the only difference being in the nature of their parietes, which are fibrous in the sinuses, but bony in the canals in question. I have remarked, that in the fœtus and new-born infants the cells of the spongy tissue which subsequently contain adipose matter, are filled with venous blood.

Lymphatic vessels have not yet been actually demonstrated in the bony tissue: but it is probable that they really exist there; at least the process of nutrition in bones and certain morbid phenomena which they present lead to the belief of their existence.

The *cellular tissue* also enters into the composition of the bones: it contributes to form their fibrous structure.

Nerves are met with in bones. I have seen a nervous twig entering the nutritious foramen of the tibia.

Development of Bones, or Osteogeny.

From the time of their first appearance in the fœtus, to the period of their complete development, the bones pass through a series of changes, which constitute one of the most important circumstances in their history. The investigation of these changes, or of the successive periods of development, is the object of *osteogeny*.

The development of the bones, considered generally, presents three phases or periods, designated by the name *mucous*, *cartilaginous*, and *osseous stage*.

1. The *mucous stage*. The mucous condition, the cellular of some authors, has not been well defined. Some apply the term to that period of formation in which the bones and the other organs of the body form but one homogeneous mass of a mucous aspect: others use the term to signify a more advanced stage, in which the bones acquiring a greater consistence than the surrounding parts begin to show their development through these more transparent tissues. In the latter sense the mucous stage is obviously nothing but the commencement of the cartilaginous, and therefore the first acceptation is the only one to be retained.

2. The *cartilaginous stage* succeeds the mucous, though the time of the transition from the one to the other has not been precisely ascertained. Several anatomists are of opinion with Mr. Howship, that the cartilaginous state does not necessarily intervene between the mucous and osseous conditions; that its occurrence is only satisfactorily demonstrated in such bones as are late in

ossifying, and that it constitutes a sort of provisional condition, in which the cartilage is employed to perform the office of bone. But when we take into consideration, in the first place, the rapid transition from the cartilaginous to the osseous stage in certain bones, and secondly, the translucency of newly formed cartilage when of inconsiderable thickness, as in the cranium, where the cartilage is scarcely to be distinguished from the two membranes between which it is placed, we can conceive that the cartilaginous stage may easily have been overlooked. On the other hand, the constant result of my observations proves that in the natural process of ossification, every bone passes through the state of cartilage.

When the different pieces of the skeleton assume the cartilaginous condition, the change occurs throughout their whole substance at once. The notion of central points of cartilaginification, corresponding with the points of ossification, is purely hypothetical: a bone becomes cartilaginous in all parts simultaneously, and never by insulated points. The cartilage has the same figure as the future bone.

Bones which are to be permanently united by intermediate cartilage, are formed from one primitive piece of cartilage, as those of the cranium and face: those on the other hand, which are connected together only by ligaments, are distinct and separable while in the cartilaginous state.

3. The *osseous stage.* The cartilaginous condition of the skeleton is completed by the end of the second month*; but ossification commences in several places long before this period. The first point of ossification appears after the fourth week in the clavicle; the second in the lower jaw. From the thirty-fifth to the fortieth day points of ossification appear sometimes successively, in other cases simultaneously, in the thigh-bone, the humerus, the tibia, and upper jaw-bone. From the fortieth to the fifty-fifth day, points of ossification appear at short intervals in the annular portion of the uppermost vertebræ, in the bodies of the dorsal vertebræ, in the ribs, the tabular bones of the skull, the fibula, the scapula, the ilium, the nasal, palatine, and metacarpal bones, the phalanges of the fingers and toes, the metatarsus, &c. Once commenced, the ossification proceeds with more or less rapidity in the different bones during the remainder of intra-uterine life.

In the child at birth, the shafts of the long, as well as the broad bones, are far advanced in development. As to the short bones, the vertebræ are scarcely less early in their evolution than the long and broad bones; the calcaneum, cuboid, and sometimes the astragalus, have points of ossification, but only commencing. The extremities of the long bones, with a single exception, the lower end of the femur, are as yet without ossifying points. The remaining short bones and extremities of long bones ossify subsequently. Of the tarsal bones, the scaphoid is the last to ossify; the pisiform is the latest among the carpal bones; the patella is ossified at the age of three years.

In regard to the process of ossification, a question of the highest interest presents itself, viz. *Is the successive appearance of the centres of ossification governed by any general law?*

The order of commencement of the points of ossification is in no way dependent on the size of the bones. It is true that the smaller bones, excepting the ossicles of the ear, are later in appearing: but at the same time it is not the largest bones that are the earliest; thus the bones of the pelvis appear long after the clavicle.

Proximity to the heart or great vessels has no effect on the precocity of development. Though the ribs which are near the heart ossify speedily, the

* [The relative time of ossification of the different bones, or at least the order in which it commences in them, is easily determined; but owing to the uncertainty respecting the age of the embryo in its early stages, the absolute time of fœtal life at which each bone begins to ossify is very uncertain, and accordingly the statements of many anatomists differ from than given in the text: thus, the seventh week is assigned by some as the period when ossification commences in the clavicle. The age fixed by the author appears too early.]

breast-bone on the other hand, which is still nearer, is one of the bones latest in ossifying. Again, the anterior and inferior angle of the parietal, which is close to the anterior branch of the middle meningeal artery, is the part of the bone which last ossifies. The femoral artery lies on the confines of the os pubis and ilium, which at that part long remain cartilaginous.

The true law which governs the order of appearance of the points of ossification is this, viz. that the period of formation is earlier or later in the several bones according to the period at which they are required to fulfil their office in the economy. Thus the jaws being required to act immediately after birth are ossified before the other bones of the head. In the same way the ribs, destined for a function which must commence from the moment of birth, are for this purpose completely ossified: the vertebræ and bones of the cranium appear early, because of their use as protecting the spinal cord and brain; and it is thus that the pretended correspondence between the rapidity of ossification and proximity to the nervous centres is explained.

Although several of the bones are completed solely by an extension of the primitive nuclei of ossification, the greater nnmber acquire, in addition to these principal or essential pieces, complementary points of ossification named *epiphyses*. Thus, while in the frontal the two original points of ossification suffice by their extension for the completion of the bone, the vertebræ, on the other hand, have three primary osseous nuclei, one for the body and two for the laminæ and processes, and five complementary pieces of ossification, namely, two for the body, and one each for the tips of the spinous and transverse processes.

The *transition from the state of cartilage to bone* is attended with the following phenomena: the cartilage becomes more dense; its colour is at first a dull white, but subsequently changes to deep yellow; small irregular cavities are formed in its substance; red vessels show themselves; a bony point appears in the midst of these vessels, and this bony nucleus is spongy and penetrated with blood. The ossification spreads by little and little, always preceded by a great development of vessels; so that, in attentively examining an ossifying cartilage, we find first an osseous point, then a red zone, next an opaque layer of cartilage which is permeated by canals, and lastly the remaining cartilage traversed only by a few vascular canals which run towards the point of ossification. Moreover, it is always at some depth within the substance of the cartilage, that the first osseous points appear, and never at the surface. It is only in cases of accidental or diseased ossification, as in the cartilages of the ribs, that it occasionally begins at the surface. It is unnecessary to pursue further the immediate process of ossification: nor need we here discuss the purely speculative question, whether the bone is really a new part essentially distinct from the cartilage, which is absorbed and gives place to it, or merely a deposit of earthy phosphate in a cartilaginous tissue.

In admitting that ossification is always preceded and accompanied by a great development of vessels, a fact proved incontestably by Haller and Bichat, I must nevertheless decidedly dissent from the opinion, that the appearance of blood in a cartilage is a constant indication of approaching ossification; for several cartilages have naturally bloodvessels, as may be seen in the cartilages of the ribs and larynx.

The study of the development of the bones does not consist merely in determining the number and time of appearance of their points of ossification: it comprehends also the ulterior changes which take place in the osseous system, viz. *the union of the primitive points of ossification, and the appearance and junction of the complementary points of ossification.* It is to be remarked, that the order of development and union of the points of ossification does not always correspond with that in which they originally appear; nay, it is often the reverse. Thus the lower epiphysis of the femur is the earliest in appearing, and it is the last in joining; whilst, on the other hand, the upper end of the radius is one of the latest of the epiphyses in appearing, but is joined to the bone

before all or nearly all the rest. The junction of the pieces of ossification is not complete till about the age of twenty-five years, at which time the lower epiphysis of the femur unites with the body of the bone.

General mode of Ossification of Eminences and Cavities. M. Serres in a very remarkable work has given, under the title of *General Laws of Osteogeny*, the results of his observations concerning the development of azygos or median bones, and of eminences and cavities; and with a rapid notice of these, we shall conclude what is to be said on the points of ossification.

1. By the *law of symmetry*, which according to M. Serres governs the development of all bones situated on the median line, every such bone is originally double, that is, composed of two separate halves, which advancing to meet each other are at last joined. Thus there are originally two osseous halves of the spinal column, and two demi-sterna. The basilar portion of the occipital, the body of the sphenoid, the cribrifrom plate of the ethmoid, the vomer, and the spinous processes of the vertebræ, have according to this view originally been double. But this law has many exceptions. Thus, although some of the pieces of the sternum are commonly formed from two lateral points, the first and the last are always or almost always developed from a single point in their middle. The bodies of the vertebræ are most commonly formed from a single primitive nucleus: the same is the case with the basilar portion of the occipital, the perpendicular plate of the ethmoid, the vomer, and the spinous processes of the vertebræ. Instances of incomplete division of bones on the median line must not be adduced in proof of the existence of two primitive points of ossification.

2. Every eminence, according to M. Serres, is developed by a special point of ossification. This is true generally: but how many eminences are formed merely by the extension of ossification from the piece which supports them! Where, it may be asked, is the special point of ossification for the articular processes of the vertebræ, the coronoid process of the ulna, the external and internal protuberances of the occipital, &c.? There are even double eminences developed from a single point, as the condyles of the femur.

3. Every cavity is formed by the union of at least two pieces of ossification; so that, when a bone furnished with a cavity consists of several pieces, the place of junction of these pieces is at the cavity. Thus the three pieces of the os innominatum meet together at the cotyloid cavity. The same law, according to M. Serres, regulates the formation of the foramina and osseous canals of every kind, as the medullary cavity of the long bones, all the canals for vessels and nerves, as the carotid, vidian, &c.: according to the same law, all the foramina in the bone of the skull are formed originally of two halves. But the facts are opposed to this doctrine when applied so universally.

Progress of Ossification in the three Kinds of Bones. 1. *In the long bones.* Ossification commences in their middle part. A small cylinder of bone appears, narrow in the middle, expanded at the ends, tubular within, perforated already with the nutritious foramen which is very obvious, and receives very large vessels. This little cylinder grows gradually thicker and longer, extending towards the extremities of the bone which it reaches about the time of birth; whilst at this period the ossification is so far advanced in the body of the long bones, their extremities are not yet osseous. It is only at later periods, varying in different bones, that an osseous nucleus appears in the cartilaginous extremities, increasing and encroaching upon the portion of cartilage which separates it from the bony shaft until that cartilaginous partition gradually becoming thinner, is at last itself invaded by the ossification. All the long bones have two essential or principal epiphyses, to which complementary epiphyses are sometimes added. The phalanges * are an exception; they have only one. It is this process which is named junction of the epiphyses. The time of its completion is not confined to any very definite limits, but it is over by twenty or twenty-five years.

* [Also the clavicle, the metatarsal, and usually the metacarpal bones.]

Throughout the whole time of development, the growth in length takes place chiefly by ossification of the intermediate cartilage, which separates the epiphyses from the shaft, but partly also by longitudinal expansion of the ossified shaft itself. The former mode of increase has been satisfactorily established by Hunter; the latter is proved by the following experiment of Duhamel:— Three needles being fixed in the shaft of a long bone of a bird at measured distances, it is found that after a certain time they become further separated, which proves that the osseous cylinder has undergone an elongation.

2. *In the broad bones.* 1. Among the broad bones those which are symmetrical often commence by two points placed one on each side of the median line. 2. The asymmetrical bones are developed sometimes from a single point of ossification, as the parietal; sometimes by several, as the temporal.

One of the most remarkable circumstances in the development of broad bones is the sort of radiation by which the deposition of calcareous phosphate extends, which spreads from the centre where the first osseous point was deposited, and advances by divergent rays to all points of the circumference, forming bony striæ separated by intervals which are soon filled up by new osseous rays. As these rays are of unequal length, and are separated at the circumference by intervals of greater or less extent, it follows that a broad bone in the process of ossification must have at its circumference a scalloped or jagged border, like the toothed edge of a comb. It is this form of ossification which gives rise to the serratures of the sutures.

The broad bones are proportionally much thinner in the early periods of ossification than subsequently, because at first the spongy texture is scarcely developed. At the time of birth the primary pieces of ossification not having united except in very few places, and the ossification which spreads from the centre of the bones not having yet reached the limits of their circumference, it follows, that the constituent parts of bones, and the edges of different bones which are destined in the end to meet together, are at this period separated by cartilaginous, and in some measure membranous intervals, which in the cranium constitute the fontanelles. After birth, ossification spreads more and more in the broad bones; at the same time they increase in hardness and thickness, appearing as if to separate into two plates or tables, the interval between which becomes filled with spongy tissue.

The epiphysary or complementary points of ossification of some of the broad bones represent, in a certain degree, the epiphyses of the long bones. They occupy the circumference, and are thence named *marginal epiphyses.* Thus in the cartilaginous border of the haunch-bone, which represents the crest of the ilium, a point of ossification commences, and extending along its whole length forms a marginal epiphysis, which subsequently joins the rest of the bone, and in this respect is perfectly analogous to the epiphyses at the extremities of the long bones. The epiphyses then are not an exclusive attribute of the long bones, as Bichat maintained. They are found also in some of the short bones. But it would be indulging in a false analogy to class the Wormian bones, formed during the development of the cranium, with the epiphyses of the long and the broad bones; for they have peculiarities which are never found in true epiphyses. Thus, 1. They are not joined by osseous union, as is the case with epiphyses, but always by suture. 2. There is no constancy in their time of appearance, nor in their figure which is irregular, nor in their size which is in general greater the earlier they have appeared, because they have then had longer time to extend themselves before meeting the neighbouring bones.

From what has been said, we conclude that the broad bones have a twofold mode of increase in breadth, namely, the successive addition of bony substance to their borders, and the formation of marginal epiphyses. In every broad bone which is formed from several pieces, and which has on its surface a part for articulation, this last becomes the centre in which the different pieces meet, and are ultimately joined when the ossification is completed.

3. *In the short bones.* These are the latest in being ossified; a great number of them are still cartilaginous at birth. The short bones are not destitute of epiphyses, as is proved by the ossification of the vertebræ and calcaneum. Their ossification in fine presents the same phases, and follows the same progress as that of the extremities of the long bones, which they resemble in so many respects.

Changes which take place in Bones after Maturity.

To obtain a complete notion of the development of the bones, we must not rest satisfied with ascertaining the number of points of ossification, their successive appearance, and their mode of junction; we must also study the changes which they undergo after they have attained their full growth.

The increase of the bones in height terminates when their several pieces have become united: the time when this is accomplished varies from the age of twenty to thirty years; but they continue to increase in thickness for a considerable time longer. In proof of this we need only compare the bones of a young man with those of an adult of forty. In old age the bones still undergo important changes: the medullary canal of the long bones augments in width, and the thickness of its parietes diminishes in proportion; and something similar takes place in the broad and the short bones.

Another important fact to be here mentioned is, that the relative proportion of calcareous phosphate and animal matter undergoes continual changes in the course of life. Thus by an analysis of Dr. I. Davy it was shown, that the proportion of calcareous phosphate was a fifth less in a child of fifteen years than in the adult. The same chemist found, that the proportion of phosphate of lime in an adult occipital was to that in an occipital bone of an aged person as sixty-four to sixty-nine.

Nutrition of Bones.

The fact of the nutrition of bones and the process of composition and decomposition in which it consists, appear to me to be demonstrated by the experiment with madder. If an animal is fed for some time with food impregnated with the juice of madder, its bones soon become coloured red, as may be ascertained by amputating a limb; but by suspending the use of that substance for some time, the bones recover their natural colour. In this experiment there is no doubt that the calcareous phosphate is the vehicle of the colouring matter, for the bones are the only parts that become coloured; all that is cartilaginous remains free from colour. We may infer from this, that a twofold movement continually goes on in bones, by which new molecules are first deposited and then removed, after they have for a longer or shorter period formed part of these organs.*

The administration of madder moreover demonstrates a fact, which was proved by Duhamel du Monceau in a very curious set of experiments, namely, that the growth of bones takes place by the successive deposition of new layers formed by the undermost or contiguous layers of the periosteum. Thus let a pigeon be fed with food impregnated with madder, suspend the use of the madder for a time, then renew it; after this, the bones when cut through exhibit a red layer next their surface, then a white layer, then a red layer again.

Thus the bones grow in two ways, namely, by the interstitial mode of growth or by intussusception which they have in common with the other tissues; and secondly, by juxtaposition.

* A somewhat subtle objection would be the following: — May not the colouring matter be deposited and again carried off without the particles of phosphate of lime being necessarily subject to the same vicissitudes?

THE VERTEBRAL COLUMN.

General characters of the vertebræ.— Characters peculiar to the vertebræ of each region.— Characters proper to certain vertebræ.— Vertebræ of the sacro-coccygeal region.— The vertebral column in general.— Development.

Fig. 1.

The *vertebral column* (from the Latin word *vertere*, to turn, because the body turns round this as an axis), *spine*, or *rachis*, is that long, flexible, hollow, bony stem, the principal lever of the body, which affords support to almost the entire skeleton, and at the same time shields and protects the spinal marrow. It is situated at the posterior and median portion of the trunk, extending from the cranium to the pelvis, where it terminates in two osseous pieces, the sacrum and coccyx, which may in fact be regarded as a continuation of the column. The *sacrum* and *the coccyx* have been separated from the vertebral column merely on account of the osseous junction of the vertebræ of which they are composed.* It is articulated with the base of the cranium at the part where the posterior joins the two anterior thirds of this cavity: it corresponds with the posterior portion of the pelvis, an arrangement most favourable for maintaining the erect position.

The vertebral column is situated behind the alimentary canal in man, above it in the lower animals. In front are suspended the organs of respiration and circulation, to which it affords protection, and which constantly tend to incline it forwards: to its sides are attached the ribs and the extremities, the thoracic having an indirect and movable, the abdominal a fixed, connexion.

From the limits here assigned to the vertebral column it follows that this part of the skeleton extends the whole length of the trunk, forming the entire osseous support of the neck and loins, the posterior column of the thorax, and even the posterior wall of the pelvis. Hence it is divided into four regions, viz. a cervical, a dorsal or thoracic, an abdominal, and a pelvic or sacro-coccygeal region.

The vertebral column (*fig.* 1.) is composed of twenty-six bones piled above each other: the last two have received the names of *sacrum* and *coccyx*, and the others which constitute the vertebral column, properly so called (*a d*) are denominated *vertebræ*: they have also been called *true vertebræ*, as distinguished from the *false vertebræ*, which by their osseous union form the sacrum (*d e*) and coccyx (*e f*). The sacrum is composed of five of these false vertebræ, and the coccyx of four, in a rudimentary state. The description of these latter bones will be deferred in the mean time. The first seven true vertebræ form the cervical region (*a b*); the twelve which succeed constitute the dorsal (*b c*); and the last five the lumbar region (*c d*).

There are occasionally, but very rarely, some variations in the number of vertebræ. In a few cases only six cervical vertebræ have been found, and Morgagni

* The same is true of anchylosis, as of certain differences of form and development, viz. that they lead *to the establishment of varieties, but* cannot form the ground of total separation.

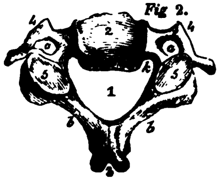
who first observed this anomaly, considers it to be a predisposing cause of apoplexy, on account of the accompanying shortness of the neck, and consequent approximation of the heart and brain. There are sometimes thirteen dorsal vertebræ: sometimes the fifth lumbar is united to the first sacral, and there are then only four lumbar vertebræ. In other cases, the first sacral vertebra is distinct from the rest, and the lumbar portion of the column then consists of six.

The vertebræ present general characters, which distinguish them from all other bones: they have also characters peculiar to each particular region; and in each group or region certain vertebræ have individual distinctive characters.

General Characters of the Vertebræ.

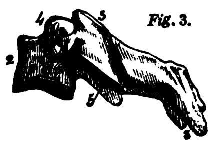
Every vertebra (*figs.* 2, 3, 4, 5, 6, 7.) is essentially a symmetrical ring, a segment of the cylinder which protects the spinal marrow, and is consequently perforated by a foramen, denominated the *vertebral* or *rachidian foramen* (1, *fig.* 2.). As it concurs also to form part of a supporting column, it presents a kind of enlargement or solid cylinder, of which the posterior fifth has been removed. This enlargement is the *body* of the vertebra (2). Each vertebra gives attachment to numerous muscles, by very marked eminences for insertion—the *spinous* (3) and *transverse processes* (4 4). It is articulated with the other vertebræ by four *articular processes* (5 5), two *superior* and two *inferior*. Lastly, it presents two *superior* and two *inferior* notches (7, *figs.* 4, 5.), which unite to form the *intervertebral foramina*, through which the vessels and nerves are transmitted.

Fig. 2.



A. *The body of the vertebra* (2) occupies the anterior portion of the vertebral ring, and presents *four surfaces*. The superior and inferior surfaces are connected with the contiguous vertebra, and are slightly hollowed for the reception of the intervertebral substance. This double excavation is the vestige of the deep biconical cavity, so remarkable in the vertebræ of fishes. The anterior surface is convex transversely, and presents a horizontal groove (2, *figs.* 4 and 5.), which is deeper laterally than in the median line, and in cases of abnormal curvature is greater on one side than on the other. This groove is the rudiment of that circular constriction which exists in the vertebræ of reptiles and fishes, and in the cervical vertebræ of birds: it has the double advantage of economy, both as to the weight and the bulk of the bone. The posterior surface is concave, and forms part of the vertebral canal. It is pierced by numerous foramina of considerable size, which are the orifices of venous canals hollowed out in the substance of the vertebra. Smaller foramina of the same nature exist also on the anterior surface.

Fig. 3.



B. *The vertebral foramen* (1, *fig.* 2.) exhibits certain variations in form and dimensions in the different regions of the spine; but in nearly all the vertebræ it approaches more or less to the triangular form. The differences which it presents in the extent of its diameters, bear reference partly to the size of the spinal marrow, and partly to the extent of motion in each region.

C. *The spinous process* (3, *figs.* 2, 3, 4, 5.) is that eminence of considerable size, which arises in form of a spine from the posterior part of the vertebral arch. It forms a lever for the extensor muscles of the trunk, and accordingly varies in length, shape, and direction, in the different regions. It bifurcates as it were at its base, and passes into the two *laminæ* (*b b*, *fig.* 1). which constitute the lateral and posterior portions of the arch.

D. *The articular processes* (5 5) arise from the lateral portions of the arch, near its junction with the body of the vertebra: their direction is in general vertical, *i. e.* perpendicular to the direction of the articulating surfaces of the body, which are horizontal. They are four in number, two *superior* or *ascending*, and two *inferior* or *descending*; they are placed symmetrically on each side of the median line, and are covered with cartilage in the fresh state, to form a movable joint with the articular processes of the adjacent vertebræ; they project beyond the level of the bodies of the vertebræ, so that their articulations correspond with the intervertebral substances. Hence the vertebral column presents two successive series of articulations, one constituted in front by the union of the bodies, the other behind by the articular processes.

E. *The transverse processes* (4 4) are lateral prolongations, which arise from each side of the vertebral ring, pass horizontally outwards, and vary in length and size in the different regions.

F. In front of the articular and transverse processes, immediately behind and at the side of the body of the vertebra, are *four notches* cut in the lateral parts of the ring (7, *figs.* 4 and 5.): the inferior are generally deeper than the superior, but their depth varies considerably in the different regions. The part of the vertebral ring between the upper and lower notches is reduced to a sort of *pedicle;* it is the weakest part of the vertebra, and consequently it is the principal seat of torsion in curvatures of the spine. The constituent parts of a vertebra are therefore, 1. In the median line, *the body*, *the foramen*, *the spinous process*, and the *laminæ;* 2. On each side, *the articular and transverse processes*, *the notch*, and the *pedicle.*

Characters peculiar to the Vertebræ of each Region.

The characters distinctive of the vertebræ of each region of the spine are most marked in those placed in the middle of the respective region, for at its extremes the vertebræ acquire intermediate or mixed characters belonging to the two regions near the confines of which they are situate. It may be remarked that the vertebræ of each region may be at once recognised by one single distinctive character: thus the cervical vertebræ are always known by a foramen in the base of the transverse processes (*a*, *fig.* 2.); the dorsal vertebræ by facettes hollowed out on the sides of the bodies (6 6, *fig.* 4.); and the lumbar (*fig.* 5.) by the absence of the two preceding marks. The characters just mentioned might then suffice as mere distinctive marks, but they would not answer the purposes of exact anatomical description. Indeed, a vertebra is cervical, dorsal, or lumbar, rather in virtue of its entire form and structure than by reason of any single circumstance pertaining to it.

Fig. 4

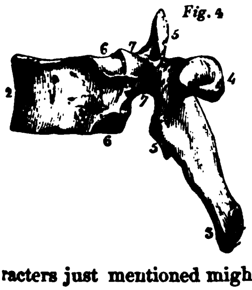
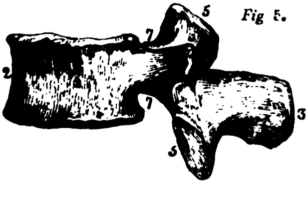


Fig 5.



We shall examine in regular order each part of a vertebra, as it exists in the different regions.

Bodies of the Vertebræ in different Regions.

The first distinctive character is their size. *This progressively increases from the cervical to the lumbar region* (*a*, *b*, *c*, *d*, *fig.* 1.): taking the size of the bodies of the lumbar vertebræ as unity, that of the dorsal would be two thirds, and that of the cervical *one half.*

The second distinctive character is the *proportion of the diameters*. In all vertebræ the transverse diameter is the greatest, and the vertical the smallest. In the lumbar vertebræ the height or vertical diameter is twelve lines (one inch), in the dorsal nine lines (three quarters of an inch), and in the cervical six lines (half an inch). In the cervical and lumbar regions, the vertical diameter of the body is less behind than before, which inequality gives rise to the anterior convexity of these regions. In the dorsal region, on the other hand, the vertical diameter is shortest anteriorly. In the lumbar region, the transverse diameter does not exceed the vertical and the antero-posterior by more than one third at most. In the dorsal region no one diameter is strikingly predominant; but in the cervical the transverse is almost double that of the antero-posterior and the vertical diameters.

The third distinctive character is formed by the *lateral ridges of the bodies of the cervical vertebra*. From the two sides of the superior surface of the bodies of the cervical vertebræ, arise two small ridges (*fig.* 2. on each side of 2), which are received into corresponding depressions on the inferior surface of the vertebra above. This mutual fitting-in of the bodies of the cervical vertebræ compensates for the less secure connexion of their articular processes.

The fourth distinctive character consists in the *two demi-facettes on each side of the bodies of the dorsal vertebræ* (6 6, *fig.* 4.). These demi-facettes when united with the corresponding parts of the neighbouring vertebræ form angular excavations, in which the posterior extremities of the ribs are received. This character belongs exclusively to the dorsal vertebræ.

The fifth distinctive character is the *excavation of the superior and inferior surfaces of the bodies, which is less in the dorsal region than in the cervical or lumbar*. From this disposition it results, that a lenticular space of a much greater size intervenes between every two of the lumbar and cervical vertebræ than between the dorsal: the mobility is consequently much increased, from the greater size of the intervertebral substance.

The specific characters, then, of the bodies of the vertebræ in the different regions are the following:—1. *Lateral ridges on the superior surface of the cervical vertebræ.* 2. *Lateral facettes on the dorsal vertebræ.* 3. *The absence of these two characters, and the preponderance of size in the lumbar vertebræ.* If the body of a vertebra be presented for our inspection, we can at once determine from these characters the region to which it belongs.

The Vertebral Foramen and the Notches in the different Regions of the Spine.

The vertebral foramen and the notches present certain marked distinctions in the vertebræ of the three regions, by which they may be recognised by a practised eye.

1. In the cervical region the transverse diameter of the foramen (1, *fig.* 2.) considerably exceeds the antero-posterior. 2. In the dorsal region, the two diameters are almost equal, but there is this much remarkable, that a very considerable depression exists on the posterior surface of the body of the bone. 3. In the lumbar region the transverse diameter is the greater, but the difference is much less remarkable than in the cervical. The following is a comparative table of the diameters in the three regions:—

Transverse diameter.		*Antero-posterior diameter.*	
In the neck	11 lines.	In the neck	6 lines.
back	7 lines.	back	6 lines.
loins	10 lines.	loins	8 lines.

It may be remarked here, that these differences correspond with the extent of motion in each region. In the lumbar region, which is more movable than the dorsal, the foramen is larger; and in the cervical region, where the

lateral motions are more extended than in the loins, the transverse diameter is still greater in the proportion of eleven to ten. It must be observed, however, that the diameters of the foramen bear reference not only to the mobility of the part, but also to the size of the spinal marrow.

The *notches* present also certain differences in the different regions; thus in the dorsal and lumbar regions (7, *figs.* 4 and 5.), the inferior are much deeper than the superior; in the cervical region they are of almost equal depth (*fig.* 3.). It may also be remarked, that the depth of the notches and consequently the size of the intervertebral foramina are generally proportional not only to the size of the spinal ganglions, but also to the capacity of the venous canals, which establish a communication between the external and internal veins of the spine. It is then possible, when only the vertebral foramen and the notches are seen, to determine the region to which the bone belongs.

The Spinous Processes and Laminæ in the different Regions.

1. *In the cervical region*, the spinous processes are prismatic and triangular (3, *figs.* 2, 3.), grooved inferiorly for the reception of the spinous process of the vertebra below during the movements of extension, and bifurcated at their summit for the purpose of muscular insertion. Their direction is horizontal and consequently favourable to extension.

2. *In the dorsal region* (3, *fig.* 4.) they are prismatic and triangular, with a tubercle at their summit: their direction is extremely oblique, approaching to the vertical. This direction, together with their great length, causes them to descend considerably below the inferior surface of the body of the vertebra. Hence a sort of imbrication, and to such a degree, that a very slight movement of extension causes them to touch each other.

3. *In the lumbar region*, the spinous processes (3, *fig.* 5.) are broad, thick, and quadrilateral, presenting on their sides a large surface for muscular insertion: their posterior border is thick, tuberculated, and triangular. Their direction being horizontal, presents no obstacle to extension.

The two laminæ (*b b*, *fig.* 2.), which form the posterior arch of the vertebra, are continuous with the base of the spinous process. Their length is directly proportionate to the dimensions of the part of the canal to which they correspond, and their thickness is in proportion to the size of the spinous process.

1. *In the cervical region*, the laminæ are thin, very long, and so inclined, that when the head is erect, *i. e.* in a position intermediate between flexion and extension, the inferior edge of the superior laminæ passes beyond the superior border of the vertebra below, so that there is a true imbrication of these laminæ, not less marked than that which we have observed of the spinous processes in the dorsal region. There has been consequently no case recorded of the entrance of any penetrating instrument into the spinal canal, in the situation of the undermost five cervical vertebræ, which fact is the more easily conceivable when we reflect, that the least impression upon the back of the neck excites instinctively an extension of the head, and thus increases the imbrication of the laminæ. 2. In the *dorsal region* the thickness of the laminæ is greater than in the neck, but still inferior to that in the loins: they are comparatively much shorter than in the cervical region, and instead of forming an elongated rectangle, they represent a square, nay, their vertical dimension almost exceeds the transverse. 3. In the *lumbar region* they are characterised by great thickness, by diminution of the transverse, and marked increase of the vertical diameter. In general it may be stated, that the height of the lamina corresponds with the thickness of the body of the vertebra to which it belongs: hence they are so narrow in the cervical region.

To sum up then the characters of the spinous processes and the laminæ:—

1. Cervical region:—*Processes prismatic and triangular, grooved inferiorly, bifurcated with two tubercles at their summit, horizontal, short*, and continuous with

long, narrow, and thin laminæ, inclined so as to become imbricated. 2. Dorsal region: — *Spinous processes, prismatic and triangular, long, oblique, and tuberculated at their summit, with short vertical laminæ.* 3. Lumbar region: — *Spinous processes quadrilateral, strong, and horizontal, with very short, thick, and vertical laminæ.* It is possible then from the spinous process and its laminæ alone to determine the region of any vertebra.

The Articular Processes in the different Regions.

In the *cervical region* (5 5, *figs.* 2 and 3.) the articular processes form small columns, and are so directed that their articular surface makes with the horizon an angle of about 45°: the superior look upwards and backwards, the inferior downwards and forwards. It is important to remark this direction, because it permits the movements of flexion, extension, and lateral inclination: it is owing to the same circumstance also, that luxations of the cervical vertebræ may occur without fracture of their articular processes. It should be also observed, that the articular surfaces of the right and left sides are in the same plane.

2. In the *dorsal region* (5 5, *fig.* 4.) the articular processes are simple laminæ, the direction of which is vertical and the surface plane. The superior look backwards and outwards, the inferior forwards and inwards. The articular facette of the right side is not on the same plane as that of the left.

I should observe, that in certain cases the dorsal articular processes are found as it were locked together, the extremity of the superior process being received into a deep notch on the surface of the inferior process of the vertebra above.

3. In the *lumbar region* (5 5, *fig.* 5.) the articular processes are very strong, with curved surfaces. The superior concave look backwards and inwards; the inferior convex, forwards and outwards. They both represent two segments of a cylinder, one of which completely surrounds the other, or rather the inferior resemble half hinges, which are received into the half rings formed by the superior processes. It should be observed here, that the superior articular processes are prolonged by certain tubercles, to which the name of *apophysary* may be correctly applied, and which serve for the insertion of muscles. To sum up then what has been said: *The cervical articular processes are small columns, cut with plane faces at an inclination of* 45°, *those of both sides on the same plane; the dorsal are thin laminæ, plane and vertical, but not in the same plane; the lumbar strong, vertical, and tuberculated laminæ, with a curved articular surface.* The region of any given vertebra may be easily recognised from its articular processes alone.

The Transverse Processes in the different Regions of the Spine.

No part of the vertebræ presents more decided variations in the different regions than the *transverse processes.*

1. In the *cervical region* (4 4, *figs.* 2 and 3.) they are grooved superiorly for the lodgment of the anterior branches of the cervical nerves: their base is perforated (*a*, *fig.* 2.) for the passage of the vertebral artery: they have two borders, an anterior and posterior, to which the inter-transversal muscles are attached: their free extremity is bifurcated for the attachment of muscles. It should be added, that these transverse processes being on the same plane with the bodies of the vertebræ, double their transverse diameter in front, and enable them to afford support to a great number of parts.

2. In the *dorsal region* (4, *fig.* 4.) they are large and horizontal, much stronger than in the other regions, and twice or three times the size of the spinous processes: they are much inclined backwards, and the anterior surface of their extremity has a depression for articulation with the tubercle of the ribs. Some anatomists have attached great importance to the direction of the articular facettes, making it the basis of their notions of the mechanism of respiration.

The important modifications which the transverse processes of the dorsal vertebræ present, are evidently connected with the nature of their functions, which are not only that of affording points of insertion to muscles, but also of supporting the ribs with which they are articulated.

3. In the *lumbar region*, the transverse processes (4, *fig.* 5.) are thin narrow laminæ, flattened from before backwards. They are situated in a plane anterior to that which the transverse processes of the dorsal vertebræ occupy, and almost correspond with that of the ribs, with which also they have numerous other analogies: hence the name *costiform processes* given them by some anatomists.* The characteristics then of the three kinds of transverse process are, *in the cervical region, a grooved projection with a foramen at the base; in the dorsal region, a strong process inclined backwards, tuberculated, and articular at the extremity; in the lumbar region, a small, thin, blunted projection.* It is therefore extremely easy to determine the situation of a vertebra by the transverse process.

The truth of what we formerly remarked will be now evident, viz. that a vertebra is distinguished as cervical, dorsal, or lumbar, by the form of all its constituent parts. Uniform in their fundamental type, these bones present in each region, and in each part, certain differences adapted to their respective uses.

Characters proper to certain Vertebræ.

We have now noticed, 1. the general characteristics of the vertebræ, by means of which they may be recognised from all other bones; 2. the peculiar distinguishing characters of the vertebræ in each region. We have now to examine in each region those vertebræ which are distinct from all the others of that part of the spine. The place of each vertebra might, strictly speaking, be determined by comparing it with all the other vertebræ of the same region: in this way those who are accustomed to articulate skeletons acquire surprising readiness. But a few vertebræ only possess sufficiently characteristic peculiarities to determine their situations without comparison with the others. It is only in the vertebræ at the extremity of each region, and which on account of their position have a mixed character, that such distinctive and individual attributes can be observed.

The first, second, and seventh cervical vertebræ, the first, eleventh, and twelfth dorsal, and the fifth lumbar, require special description.

First Cervical Vertebra, or Atlas (fig. 6.).

In the *first vertebra*, or *atlas*, the place of the body is supplied by an arch (*a g*), flattened from before backwards, *the anterior arch of the first vertebra.* Its convexity turned forwards is marked by a tubercle (*a*), *the anterior tubercle of the atlas.* Its concavity, looking backwards, presents an oval facette, slightly hollowed for articulation with the odontoid process of the second vertebra. The superior and inferior borders afford attachment to ligaments.

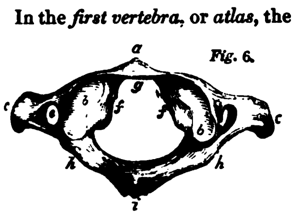


Fig. 6.

The *foramen* of the first vertebra is much larger than that of all the others. The antero-posterior diameter, which in the neck and back is six lines, and in the loins eight, is here fourteen; the transverse diameter eleven lines in the neck, seven in the back, and ten in the loins, is here thirteen. This remarkable extent of all the diameters is not simply owing to the size of the spinal marrow

* The description which we have given of the transverse processes is in accordance with that usually found in works on human anatomy. Several modern anatomists, however, do not admit of the arrangement which we have adopted. From the existence of cervical and lumbar ribs in the skeletons of many vertebrated animals, they maintain that in man, the anterior half of the cervical transverse processes, and the thin plates of the lumbar transverse processes, represent the ribs of the dorsal region; while the parts truly analogous to the dorsal transverse processes are, 1. in the cervical region the posterior half of the transverse process; 2. in the lumbar region those projections which we have called apophysary tubercles.

at this point, for the anterior portion of the foramen (*f, g, f*) gives lodgment to the odontoid process of the second vertebra, so that the antero-posterior diameter of the part which contains the spinal cord does not greatly exceed that of the foramen in the succeeding vertebræ. The transverse diameter alone is more considerable, whence the possibility of lateral displacements or incomplete luxations of the first upon the second vertebra without any marked compression of the cord.

The *notches* (*h h*) are situated on the posterior arch at its junction with the lateral masses. They are posterior to the articular processes, whilst in all the other vertebræ they are anterior. The *superior* are very deep, often converted into a foramen by a bridge of bone, and seem to be continuous with the foramen in the base of the transverse process, by means of a horizontal groove which winds round behind the articular process. This groove is sometimes almost converted into a complete canal. From the union of these parts, viz. the notch, groove, and foramen, a *twisted canal* results, vertical at first and afterwards horizontal, along which the vertebral artery runs in its passage into the cranium. Through the superior notch, which almost forms by itself the first intervertebral foramen, the vertebral artery and vein and the first cervical nerve pass. The *inferior* notches present nothing remarkable, excepting that they are sufficiently deep to form by themselves the intervertebral foramen between the first and second vertebræ.

There is no *spinous process*: its place is supplied by a *posterior tubercle* (*i*) for muscular insertion, analogous to the anterior tubercle, or more correctly resembling a spinous process truncated. Sometimes, instead of a tubercle, there are only some inequalities. The *posterior arch* (*h, i, h*), which forms, more than half the circumference of the vertebra, consists of two strong and long plates.

The *articular processes or columns*, which we have remarked throughout the whole cervical region, are very large in the atlas, and bear the name of *lateral masses*. This structure is connected with the use of the bone, which is to support the occipital condyles, and consequently the weight of the head.

Of the four articular processes the superior (*b b*) are concave, slanting inwards, oval, and obliquely directed from behind forwards, and from without inwards. Their form exactly corresponds with the convexity of the occipital condyles (7 7, *fig.* 10.), which they receive, and for this purpose their external borders and posterior extremities are considerably elevated. Within and below the articular surface are certain inequalities (*f f*, *fig.* 6.), which give attachment to the transverse ligament. The *inferior* articular processes are circular and plane; they look downwards and a little inwards.

The *transverse processes* (*c c*) are very large and triangular: they have only one tubercle, into which are inserted the principal rotatory muscles of the head: they are perforated by a foramen (*e*) at the base, but are not grooved on their surface.

The characteristics then of the atlas are, *an annular form—great lateral dimensions, so that it surmounts the vertebral column like a capital—a very large vertebral foramen—no body, nor spinous process—large lateral masses, supporting very strong transverse processes, which are not grooved, and have only one tubercle.*

Second Vertebra, Axis, or Vertebra Dentata (*fig.* 7. side view).

The body is surmounted by an eminence (*g, a, l, fig.* 7.), which in the connected skeleton corresponds with the anterior arch of the atlas. This eminence has received the name *odontoid process*, or *processus dentatus*, from its tooth-like form. It constitutes a species of cylindrical pivot about half an inch in length, round which the head turns; and hence the name *axis* given to the entire vertebra. It is attached to the body of the bone by a broad basis, is then constricted, and terminates superiorly in an enlargment called the head, which is rough at its summit (*a*), and gives attachment to the odontoid ligaments. The contracted portion (*l*) is called the *neck*; it is the weakest part of the process, and is consequently the invariable seat of its fractures. This circular

constriction of the inferior part of the odontoid process contributes to maintain it in the semi-osseous, semi-ligamentous ring in which it turns. Two articular facettes are seen on this process, one in front (*g*) corresponding with the anterior arch of the atlas, the other behind (at *l*) for the transverse ligament.

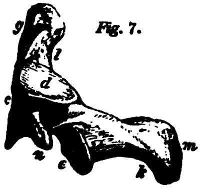


Fig. 7.

The *body* (*c*) of the axis presents anteriorly a triangular vertical ridge, which separates two lateral depressions for the attachment of muscles. The posterior surface corresponds with the vertebral canal. The greatest diameter of the inferior surface is the antero-posterior: it is obliquely sloped downwards and forwards, and slightly concave, for the reception of the body of the third cervical vertebra. This mutual reception of the two bones does not take place between any of the succeeding vertebræ.

The foramen is shaped like the figure of a heart on playing cards: its antero-posterior diameter is eight lines, which is two lines more than in the other cervical vertebræ, and its transverse diameter is the same. This great size of the foramen of the second vertebra corresponds with the extent of the movements between it and the atlas.

There is no *superior notch*, the inferior notch of the atlas forming by itself the intervertebral foramen. The inferior notch presents nothing peculiar.

The spinous process (*k*, *m*), though of great length, is even more remarkable for its breadth and thickness, presenting as it were, in an exaggerated degree, the characters of the cervical spinous processes: its form is prismatic and triangular; it is grooved inferiorly, and terminates by two tubercles for the attachment of powerful muscles. The spinous process is for the axis that which the transverse process is for the atlas, both giving insertion to powerful muscles which move the head upon the vertebral column.

The *laminæ*, which correspond as usual with the size of the spinous process, are remarkably strong.

The superior articular processes (*d*) are placed, on each side of the body. Their facettes are broad, flat, and almost horizontal, being slightly inclined outwards. This direction permits the atlanto-axoidean articulation to be the centre of all the rotatory movements of the head.

The *inferior articular processes* (*e*) resemble those of the other cervical vertebræ.

The *transverse processes* (*n*) are small, with only one tubercle, triangular, bent downwards, and perforated at the base by a foramen (*f*) or rather a bent canal, which is hollowed out on each side of the body of the bone; and is vertical in the first part of its course, then horizontal. This canal, and that which we have described upon the atlas, mark the winding course of the vertebral artery before it enters the cranium.

The specific characteristics then of the second vertebra, are *the odontoid process, the great size of the spinous process and the laminæ, the large size and horizontal direction of the superior articular processes, which are placed on each side of the body, and the shortness of the transverse processes, which are triangular and have one tubercle.*

Seventh Cervical Vertebra, or Vertebra Prominens (*b*, *fig.* 1.).

The *body* has the ordinary characters observed in the cervical vertebræ, but in size it resembles that of the dorsal vertebræ, and frequently presents laterally a small impression for articulation with the head of the first rib. The *spinous process* bears the greatest resemblance to those of the dorsal vertebræ: it is pyramidal, terminates in a single tubercle, and is of great length, projecting considerably beyond the level of the other cervical vertebræ; hence its name of *vertebra prominens*. The articular processes are almost vertical, and are not supported by small columns. The *transverse process*, although grooved and perforated at the base as in all the other cervical vertebræ, closely approaches to the characters of the dorsal. The posterior border of the groove,

or posterior root of the process is thick, tubercular, and exactly similar to a dorsal transverse process, while the anterior is thin and rudimentary, excepting in cases where it is separated from the body of the bone, and forms a supernumerary rib.* The *foramen* in the base of the transverse process is very rarely absent, but is most commonly small: in one case only I have found it double. It is never traversed by the vertebral artery.

First Dorsal Vertebra.

This vertebra resembles the cervical, in having its body surmounted laterally by two hook-like processes or ridges, but in all other respects it is strictly analogous to the other dorsal vertebræ. It should be also observed, that the body presents an entire facette for the first rib, and a third or fourth part of another for the second.

Eleventh and Twelfth Dorsal Vertebræ.

The eleventh dorsal vertebra presents on each side of the body an entire facette for the eleventh rib. Its body is very large, and the place of the transverse process is supplied by a tubercle.

The twelfth dorsal vertebra (*c*, *fig.* 1.) resembles the lumbar in its body, which is scarcely smaller than that of the lumbar vertebræ, and of which the transverse diameter begins to predominate. The spinous process is horizontal, strong, and quadrilateral. The transverse processes are represented by tubercles, which, like those of the preceding bone, are evidently continued in the lumbar region by those tubercles which we have denominated apophysary. Lastly, the body presents entire articular facettes. It is distinguished from the eleventh dorsal vertebra by the curved surface of the inferior articular processes.

Fifth Lumbar Vertebra.

The inferior surface of the body slopes very obliquely downwards and forwards. The transverse processes vary in size, but are generally much larger than those of the other lumbar vertebræ; the inferior articular processes, which are further separated from each other, have a flat surface, and look directly forwards.

These are the only vertebræ which in each region present peculiarities. Excepting the first and second cervical, which have many characters quite foreign to the vertebræ of the region to which they belong, it might be said of those peculiar vertebræ which have been specially described, that their peculiarities are comprehended in the general statement that those vertebræ which are placed at the limits of any two regions possess characters belonging to both regions.

Vertebræ of the Sacro-coccygeal Region.

All the vertebræ of this region, nine in number, are in the adult state united into two bones: the five superior form the *sacrum*, the four inferior the *coccyx*.

The Sacrum (*d*, *e*, *fig.* 1 and 8.).

The *sacrum* has received its name from the alleged practice of the ancients of offering this part of the victim in sacrifice. It occupies the posterior and median part of the pelvis, behind the point where this cavity articulates with the thigh bone, an arrangement advantageous for the erect position. It is inserted, like a wedge, between the two haunch bones. Above, it corresponds with the true vertebral column, below with the coccyx. It is directed obliquely backwards and downwards; hence the column represented by the sacrum forms an obtuse angle with the lumbar column,

* This circumstance is one of the facts appealed to with most success by those who make the distinction of *transverse* and *costiform* processes.

the projection of which is anterior. This angle is denominated the *promontory*, or the *sacro-vertebral angle* (*d. fig.* 1.): it is an important object of study, both with reference to the mechanism of standing, and in the practice of midwifery.* The sacrum is curved upon itself, from behind forwards, so as to present an anterior concavity. It is the largest of all the bones of the vertebral column; hence the name of *great vertebra* applied to it by Hippocrates. It is proportionally more developed in man than in any other mammiferous animal, which is connected with the erect bipedal attitude and the sitting attitude which belong to him in a special manner.† The form of the sacrum is that of a quadrangular pyramid with a truncated apex, the base looking upwards. It is symmetrical like all the median bones, and presents for consideration *an anterior*, *a posterior*, and *two lateral surfaces*, *a base*, and a *summit*.


Fig. 8.

The *anterior*, *pelvic*, or *rectal surface* (*fig.* 8.) forms part of the cavity of the pelvis. Its concavity varies much in different individuals, and in the two sexes: but on this latter point there is great diversity of opinion among anatomists. Some believe that it is greater in the female, whence it is said results the advantage of a larger capacity of the pelvis, and consequently an increased facility for the passage of the head of the fœtus during parturition. Others, on the contrary, contend that the male sacrum is more curved, and that of the female almost straight; and they argue that, had the opposite been the case, the coccyx which forms a continuation of the curve of the sacrum would have been directed forwards, and thus diminished the antero-posterior diameter of the outlet of the pelvis; whereas, with a slight curve of the sacrum, the coccyx has no tendency to project, but is easily bent backwards during labour.‡

In order to determine the validity of these opposing statements, I have compared a great number of sacra from both sexes, but I could never detect any difference sufficiently marked or constant to be considered as characteristic of the sex.

The anterior concavity of the sacrum is interrupted by four transverse projections (1 1 1 1, *fig.* 8.), which correspond with the points of union of the sacral vertebræ, and are analogous to the intervertebral prominences. The first is sometimes so prominent, that it might be mistaken for the sacro-vertebral angle in an examination *per vaginam*.

On each side of the median line, are the anterior sacral foramina (2 2 2), four in number, the two superior much greater than the two inferior. They give passage to the anterior branches of the sacral nerves, to the sacral veins, and some small arteries. External to these are grooves for the nerves, and the attachment of the pyramidalis muscle. The anterior surface of the sacrum is contiguous to the rectum which follows its curvature.

Posterior, spinal, or cutaneous surface. Its convexity is exactly proportioned to the anterior concavity. 1. In the *median line* it presents the *sacral ridge*, formed by a continuation of the spinous processes of the vertebral column. This is often entire in its whole length, but sometimes interrupted: it bifurcates

* The sacro-vertebral angle is most remarkable in man, because he alone is destined for the erect posture. By this angle the impetus of movement transmitted from the vertebral column to the sacrum is in part destroyed. In midwifery it explains the rarity of median positions of the vertex.

† Birds which, like man, are biped, are also remarkable for the size of their sacrum.

‡ A very great curvature of the sacrum diminishes not only the antero-posterior diameter of the inferior, but also that of the superior aperture of the pelvis; and it thus opposes the ascent of the uterus from the true into the false pelvis. Accoucheurs cannot too carefully study the varieties presented by the curvature of this bone. The sacrum is often affected by a species of rickets, when the other bones of the pelvis are free from deformity; and this fact may be easily explained by a reference to the uses of this bone in supporting the whole weight of the trunk.

inferiorly, and forms the borders of the groove which terminates the sacral canal. The sacral ridge is rarely found cleft throughout its whole length.

2. *On each side of the median line* are two shallow grooves, named *the sacral grooves:* they are continuations of the vertebral grooves; they are pierced by *four posterior sacral foramina*, smaller than the anterior foramina, and differing less from each other in diameter. These afford passage to the posterior branches of the sacral nerves, to some veins and arteries. They are bordered by two ranges of unequal projections: the first row placed interior to the foramina, represent the articular processes united together; the second, external to the foramina, are more marked, and correspond with the transverse processes also united.

The *lateral surfaces* (*d*, *e*, *fig.* 1.) are triangular, broad above, narrow below, where they constitute mere borders. They slope obliquely from before backwards and from without inwards, so that the sacrum is wedged between the haunch bones in an antero-posterior as well as in a vertical direction. In front is a demi-oval or crescentic surface (7, *fig.* 8.) compared from its shape to the human ear, and hence denominated *auricular surface.* In the fresh state it is covered with cartilage, and articulates with the os innominatum. Behind, it is a very rugged surface with irregular depressions, giving attachment to the posterior sacro-iliac ligaments. The sinuous border which terminates each lateral surface inferiorly gives attachment to the sacro-sciatic ligaments.

The *base* presents, 1. in the middle an oval facette (3, *fig.* 8.), in all respects similar to the body of a lumbar vertebra, with the last of which bones it is articulated. Behind this is a triangular aperture resembling the foramen of other vertebræ, and completed posteriorly by two *laminæ*, which unite and form a spinous process *, the commencement of the sacral ridge; 2. on each side, *two triangular surfaces* (4 4.), smooth, looking forwards and upwards, and constituting part of the greater or *false* pelvis. They are separated from the anterior surface of the sacrum by a blunt edge, which forms, as we shall afterwards see, a portion of the superior aperture of the pelvis. Behind the oval surface of the body are *notches* which complete the last intervertebral foramina; and behind these notches are the *articular processes* (5 5), which resemble the superior articular processes of the fifth lumbar vertebra, and receive the inferior processes of that bone.

The *apex* (6) is truncated, and presents a transverse elliptical surface, which articulates with the base of the coccyx. Behind it, is the termination of the sacral groove bounded by two small apophyses, intended to unite with two similar projections of the coccyx. These are *the small cornua of the sacrum.*

The *sacral canal.* The termination of the vertebral canal is prismatic and triangular, wide superiorly, contracted and flattened inferiorly, where it degenerates into a groove which is converted into a canal by ligaments. This canal lodges the sacral nerves, and communicates both with the anterior and posterior sacral foramina.

The Coccyx (8, 9, *fig.* 8.).

This consists of four, rarely of five, pieces of bone: they are flattened from before backwards, and diminish successively in size from the first to the last: they are commonly united together, rarely separate, the largest corresponding with the apex of the sacrum; the smallest is a mere nodule of bone, generally unattached. The whole knotted-like bone thus constituted has a triangular shape, and follows the direction of the lower part of the sacrum. It may be regarded as the rudiment of the tails of the lower animals. In some cases I have seen it form a right angle, or even an acute angle with the sacrum.

* I have seen this spinous process completely bifurcated.

1. The *posterior, spinal or cutaneous surface* is rough for the insertion of the aponeurosis of the *gluteus maximus*.

2. The *anterior surface* resembles the same part of the sacrum in miniature, and, like it, is in immediate proximity to the rectum.

3. The *borders* are narrow, sinuous, and tubercular, and give attachment to the sacro-sciatic ligaments.

4. The *base* is often united by bone to the sacrum, even in young subjects; it presents an elliptical articular surface, exactly corresponding with that on the lower end of the sacrum. Behind are two processes directed upwards (cornua of the coccyx, 8 8, *fig.* 8.), which are sometimes continuous with the small cornua of the sacrum. Externally are two *notches*, which are converted into foramina by means of ligaments, and afford passage to the fifth pair of sacral nerves.

5. The *apex* (9) which is sometimes enlarged and sometimes bifurcated, gives attachment to the levator ani muscle. It is not uncommon to find the last pieces of the coccyx deviating from the median line.

Of the Vertebral Column in general.

Having already described the situation of the vertebral column, we shall now consider its dimensions as an entire piece of the skeleton.

Dimensions of the Vertebral Column.

1. The *length or height* of the vertebral column does not correspond with the length of the spinal marrow, which does not extend below the first lumbar vertebra. It varies at different ages, most commonly it increases up to the twenty-fifth year, but occasionally its growth is completed before this period. In the adult it remains unaltered, but in old age it becomes shortened by the incurvation of the trunk forwards, and the yielding of the bodies of the vertebræ and the intervertebral substances. This latter cause is also productive of a very appreciable shortening of the trunk, sometimes to the extent of half an inch after long walking or standing.

When measured along its curvatures, the length of the column is generally two feet four inches; in vertical height it is two feet two inches. These dimensions are not exactly proportional to the height of the individual, which depends principally upon the length of the lower extremities. In this respect I have never found any marked difference between tall and short persons. In an adult of medium stature, the cervical portion measures five inches and a half, the dorsal nine inches and a half, the lumbar six inches and a half, and the sacro-coccygeal six inches and a half.

It may be easily conceived, that in cases of abnormal curvature the vertical height must present considerable differences, while the actual length of the column may remain almost constant. In the skeleton of a female affected with rickets, a vertical line, stretched from the tubercle of the atlas to the base of the sacrum, measured one foot, six inches, and six lines, while a line which followed the inflexions of the column measured two feet eighteen lines, giving a difference of seven inches. Hence the possibility of a rapid and considerable increase in length in those patients who are submitted to continued extension.

2. *Antero-posterior dimensions.* The antero-posterior diameter, at the sacro-vertebral angle and in the lumbar region, is three inches; in the dorsal region, two inches four lines; in the middle of the cervical region, one inch six lines.

3. *Transverse dimensions.* The transverse diameter is eighteen lines in the lumbar region, thirteen in the middle of the dorsal, and twenty-two in the cervical. It should however be remarked, that the transverse processes are included in this measurement of the cervical region, but not in the others.

Direction.

The general direction of the spinal column is vertical, but it presents certain *alternate curvatures*. There are four antero-posterior curvatures, viz. in front a convexity in the neck (*a*, *b*, *fig.* 1.), a concavity in the dorsal region (*b*, *c*), a convexity in the loins (*c*, *d*), and a concavity in the sacro-coccygeal region (*d*, *e*, *f*). Behind, the opposite curvatures are observed. The degree of each curvature is always proportioned to that of the others: thus, if there be a remarkable projection in the cervical region, there is a corresponding degree of concavity in the dorsal, and a proportional convexity in the lumbar regions. So great indeed is the mutual dependence of these curvatures, that the slightest modification of one produces corresponding alterations in all the others.

There are many individual varieties of these curvatures: their effect appears to be that of augmenting the power of resistance in the vertical direction, or at least of diminishing the effect of vertical pressure. It may be physically demonstrated, that of two similar rods made of the same materials that which presents alternate curves will support a greater amount of pressure in the vertical direction than that which is straight, on account of the decomposition of forces which occurs at each curvature.

In addition to these antero-posterior curvatures, there is at the level of the third, fourth, and fifth dorsal vertebræ a *lateral inclination*, the concavity of which is on the left side. This being the exact situation in which the *aorta*, the principal artery of the body, makes a curve downwards, some anatomists have ascribed the concavity of which we speak to the curvature of this vessel. Bichat imagined it to be owing to the almost universal habit of employing the right hand, in which action the upper part of the trunk is inclined to the left, so as to afford a point of support, and as it were a counterbalance to the action of the right arm, which inclination by frequent repetition becomes permanent. According to this hypothesis, left-handed individuals should present a curvature in the opposite direction, and Béclard has shown that such is in reality the case. I may add that I have always found the deviation greatest in those who used their right arm in the most laborious employments. Of late years it has been supposed that the lateral curvature depended upon the position of the fœtus in utero: had this been the case, it should exist at birth which, as I can affirm, it never does. Notwithstanding the likelihood of Bichat's opinion, yet if we consider that in every case in which an artery is immediately contiguous to a bone, that bone presents a corresponding depression, it may be questioned whether the opinion of the older anatomists has not more foundation than is generally admitted. However slight this lateral incurvation may be, it always produces a correspondent one in the lumbar region, though in the majority of cases this is scarcely perceptible.

The history of abnormal curvatures or deviations belongs to pathological anatomy. I shall only observe that they are all due to the following causes: 1. The wasting of the vertebræ by caries or softening. 2. Want of equilibrium between the strength of the vertebral column and the weight of the body, either alone or when loaded with burdens. 3. Muscular traction. 4. The frequent repetition of any attitude in which the column is curved.

Figure and Aspects.

Viewed in front the vertebral column represents two pyramids united by their bases. The inferior pyramid is constituted by the sacrum and coccyx; the superior pyramid is the true spine; its base rests on the former, and its summit is surmounted by the atlas.

The contraction which exists at the fourth and fifth dorsal vertebræ has led to the subdivision of this superior pyramid into two others, united by their summits. Other subdivisions have been instituted, which we shall not point out, since they are useless. What it is important to know is that the vertebral

column increases progressively in size from above downwards, but that there are partial enlargements in different parts, as, for instance, in the first two cervical vertebræ, in the seventh cervical, and last dorsal, &c.

Upon the whole, it may be said that the vertebral column presents in front the appearance of a knotted cylinder; behind, that of a triangular pyramid, bristled with eminences and perforated with holes.

The vertebral column presents for consideration an anterior, a posterior, and two lateral surfaces, a base, and a summit.

Anterior surface. Here are observed, 1. The curvatures already described; 2. The range of bodies of the vertebræ, having the form of small columns piled on each other, and separated in the fresh state by certain prominent disks of a white colour and fibrous structure. 3. A range of transverse grooves on the bodies of the vertebræ, which are deeper in the aged than in the young subject. This surface presents in its transverse diameters those variations which we have already noticed. The parts placed in front of the vertebral column are, 1. Immediately on its anterior surface a ligamentous layer, which completely invests it, with the anterior recti muscles of the head, the longi colli, the crura of the diaphragm, and the psoæ muscles. 2. At a greater distance the alimentary canal, which rests on the spine at its commencement and termination, and is attached to it by membranous connexions, even where it advances forwards to form its numerous convolutions. 3. The organs of circulation, viz. the heart, the aorta in almost its whole extent, the carotid, vertebral, and common iliac arteries, the venæ cavæ, the jugular and common iliac veins, the vena azygos, and the thoracic duct. From this position of parts arises the possibility of effectually compressing the arteries against the vertebral column, a method which has been successfully adopted with the carotid arteries and abdominal aorta. It also explains the marked pulsations in the abdominal region frequently observed in emaciated subjects, and often giving rise to an erroneous suspicion of aneurism. 4. The trachea and the lungs. 5. The great sympathetic nerves are connected with it in its entire extent.

Posterior surface. This presents, 1. *in the median line* the row of spinous processes, the whole of which constitute a vertical crest or ridge denominated *spine*, and hence the names spinal column and rachis (ῥαχὶς, spine). This ridge commences with the tubercle of the first vertebra, is suddenly enlarged at the second, diminishes again at the third, fourth, and fifth cervical vertebræ, and projects anew at the sixth, and more remarkably at the seventh; thence named vertebra prominens. Below this point the processes become oblique, prismatic, triangular, and with one tubercle: their obliquity increases, but they become more slender from the first to the tenth: in the tenth, eleventh, and twelfth dorsal, they become horizontal, shorter, and stronger; and they are broad, square, rectangular, and horizontal in the lumbar region. Lastly, the ridge gradually sinks down in the sacro-coccygeal region, when it ends by dividing into two smaller ridges, leaving between them a furrow, which is continued along the coccyx.

The spinal ridge being the only part of the vertebral column which we can see or feel in the living subject, it is clearly of the greatest importance to study the slightest differences which it presents, because it is thus alone that we are able to judge of the extent of deviation of the column; and yet the indications it affords are not absolutely certain, because the pedicles of the vertebræ being susceptible of torsion, a curvature may exist in the bodies of the vertebræ without any corresponding alteration of the spinous processes.

2. *On each side* of this median ridge are two grooves, broad and shallow in the cervical, broad and deep in the upper part of the dorsal region, contracted at the lower part of the back, enlarged again in the loins and at the base of the sacrum, contracted and finally obliterated at the lower part of this bone. These grooves are filled by a muscular mass, which in robust individuals projects beyond the spine, whilst in those who are emaciated the ridge forms the most prominent part.

Lateral surfaces. These present, 1. in front, the sides of the bodies of the vertebræ and their transverse grooves, which are deeper at the sides than in front, also deeper in the loins than in the neck and back; 2. in the dorsal region, facettes for the costo-vertebral articulations; 3. still more posteriorly the *intervertebral foramina.* The largest of these foramina is the one situated between the fourth and fifth lumbar vertebræ: from this point they gradually diminish in size to the upper part of the back: in the cervical region again, they are somewhat larger; and in the sacro-coccygeal they are double, with an anterior and a posterior opening*, in consequence of the lateral conjunction of the false vertebræ of the sacrum. In general their dimensions are in proportion to the size of the veins which communicate between the intra and the extra-vertebral venous system. Between these foramina are the transverse processes which contribute to form the sides of the posterior grooves, and, between the transverse processes, the articulating processes are visible.

The *base and the summit* of the vertebral column have been already considered, in the special description of the atlas and the fifth lumbar vertebra.

Vertebral canal. This canal, into which the intervetebral foramina open, follows all the curves of the spinal column, but does not altogether correspond in shape with its external figure. It may be even said that its dimensions, at different heights, bear an inverse proportion to those of the column; thus while the canal is most capacious in the neck, the column, on the other hand, is largest in the loins. It has been said that the widest portions of the canal correspond with the enlargements of the spinal cord: but this is not correct. The capacity of the canal is proportioned to the mobility of the respective portion of the column, so that in the most extensive movements, the spinal marrow is effectually guarded from compression: thus it is largest in the neck and loins, and smallest in the back and sacrum.

The canal is almost equally well protected in front and behind: anteriorly by the bodies of the vertebræ, posteriorly by the spinous processes, which, as it were, ward off mischief from the spinal canal. Laterally it is defended by the articular and transverse processes. Behind, on each side of the median ridge, it is protected by the laminæ, the intervals of which are filled up by what are named the *yellow ligaments.* Any loss of security, occasioned by the existence of these yellow ligaments, is compensated by the following circumstances:—1. The ligaments are very short, so that the edges of the laminæ are almost contiguous. 2. In the neck, where the intervals are greatest, the laminæ are so inclined that the inferior border of the one above overlaps the superior border of the one below. 3. In the loins, where the intervals are nearly as great, the laminæ are small, and their place is in a great measure occupied by the lateral masses and the pedicles, which are proportionally increased in development. It is impossible for an instrument to penetrate into the canal in the lumbar region, excepting between the spinous processes. The same difficulty exists in the cervical region during extension, on account of the imbrication of the laminæ. During forcible flexion, however, an instrument may enter between them, when directed from below upwards.

Internal Structure of the Vertebræ.

Excepting the thin external layer of compact tissue, the bodies of the vertebræ are almost entirely composed of open spongy texture. The different processes, on the other hand, have a considerable quantity of compact tissue; but in all places where they undergo any enlargement, they are cellular. The laminæ are formed almost exclusively of compact tissue. This abundance of the spongy tissue explains the fact of the weight of the spinal column being so inconsiderable in proportion to its size.

* [The foramina which lead from the sacral canal are single at their internal orifices, though for the reason given in the text, they open externally by two orifices. It is the internal orifice which answers to the inter-vertebral foramen of the other vertebræ.]

The venous canals are larger in the vertebræ than in any other bones. They are for the most part arranged within the body of the bone in the following manner. A single canal directed horizontally, and from behind forwards, commences at the posterior surface of the body of the vertebra; at the distance of a few lines from its commencement, it divides into two, three, or four canals, which diverge from each other, and terminate partly upon the anterior surface of the bone, partly in the cells in its interior: all these canals are lined by a thin layer of compact tissue, and perforated by foramina.

Development.

The development of the vertebral column comprises, 1. That of the vertebræ in general; 2. That of certain vertebræ which differ from the rest; and 3. That of the column considered as a whole.

Development of the vertebræ in general. Each vertebra is developed at first from three points of ossification *, viz. one median for the body, and two lateral for the rest of the vertebral ring. To these primitive points are added, at different periods, five secondary or epiphysary points, viz. one for the summit of each transverse process, one for the summit of the spinous process, and two for the body, the one on the superior surface, the other on the inferior surface, where they form two very thin plates, so that at one time the body of every vertebra of the spine is in fact a triple disk. Lastly, there is a complementary point for each apophysary tubercle of the lumbar vertebræ.

The first osseous points generally appear in the laminæ; they precede, by some days, the deposition of bone in the bodies. This law, however, as Béclard has remarked, is by no means general.

The first ossific points are visible from the fortieth to the fiftieth day; that in the body occupies the centre of the cartilage, under the form of an osseous granule, which extends horizontally, so as to present a lenticular aspect. The points of ossification of the laminæ appear in the situation of the future transverse and articular processes.

The complementary osseous points are not formed until the fifteenth or eighteenth year. Sometimes, however, as Bichât has observed, the point for the summit of the spinous process is included among the primitive nuclei, and in such cases it is situated at the place where that process becomes continuous with the laminæ.

The lateral osseous points are always united together before joining the body of the bone: this union commences about a year after birth; they are not united with that of the body until about four years and a half. The lateral points are so joined to the central one that they form the sides of the body, and in the cervical region, from their more rapid increase, they constitute of themselves fully two-fifths of the body of the vertebra. It is then on the body of the vertebra, or on what is essentially the *articular* part of the bone, that the three primitive points are united together. The epiphysary points of the transverse and spinous processes, are joined to the rest from the twentieth to the twenty-fifth year; the union of the epiphysary laminæ of the bodies is not completed until from the twenty-fifth to the thirtieth year.

Development of particular vertebræ. Those vertebræ which present great differences of form, present striking differences also in their mode of development; such are the atlas, axis, seventh cervical vertebra, first lumbar, and those which constitute the sacrum and coccyx.

Atlas. Modern anatomists admit five or six points of ossification for this bone; one or two for the anterior arch, two for the lateral masses, and two for the posterior arch. I have never observed more than two lateral points, the same

* Some anatomists admit two primitive points for the body of the vertebra. It would exceed our limits to give an account of the discussions to which this question of osteogeny has given rise.

point belonging at once to the lateral masses, and half of the arch on each side. They appear in the following order: — those for the posterior arch make their appearance from the fortieth to the fiftieth day; those for the anterior arch not until during the first year after birth. The two osseous points of the posterior arch unite together, those of the anterior arch do the same, and then the anterior is united to the posterior arch.

Axis. There are often two osseous points for the body of this bone, and always two lateral ones for the odontoid process: it has, therefore, in all five or six points, viz. two for the laminæ or posterior arch, one or two for the body, and two for the odontoid process. Meckel and Nesbit admit one other nucleus between the odontoid process and the body, which appears in the course of the first year after birth. The points in the laminæ appear from the fortieth to the fiftieth day; those in the body during the sixth month; and those in the odontoid process, a short time after. At birth the body of the axis is proportionally more developed than that of the other vertebræ. The union of its several parts takes place in the following order: — the two laminæ are joined together shortly after birth; the two points of the odontoid process remain distinct during the whole of the first year; the body and the odontoid process are united in the course of the third year; and the laminæ and the body during the fourth or fifth year.

Seventh cervical vertebra. Independently of the osseous points common to all the vertebræ, this bone has two others situated on each side of the body in the cartilage which forms the anterior half of the transverse process. The existence of this point, which was described by Hunauld, but which does not appear to me to be constant, establishes an analogy between the transverse processes of the cervical vertebræ and the ribs; it represents in a rudimentary state the permanent cervical ribs of some animals; and explains an anomaly which is not very uncommon in the human subject, viz. the existence of a supernumerary cervical rib.

First lumbar vertebra. Its transverse process is sometimes developed by a point which remains separate from the body of the bone, and forms a *supernumerary lumbar rib.*

Development of the sacrum and coccyx. The first three sacral vertebræ each present five primitive points, viz. one for the body, two for the laminæ, and two for the anterior portion of the lateral masses. The last two sacral vertebræ have only three points.

Each of the coccygeal vertebræ is developed from one point only, but it is not uncommon to see the first two formed by two lateral points, which subsequently unite in the median line: there are, therefore, twenty-one primitive points in the sacrum, and four in the coccyx. Subsequently two epiphysary laminæ are formed for the body of each sacral vertebra, making ten new complementary osseous points. At a still later period two laminæ are developed, one on each side of the sacrum, corresponding with the auricular surface, so that the whole number of osseous points in the sacrum is thirty-three.

Ossification proceeds more slowly in the sacral and coccygeal vertebræ than in the others: it commences in the body, the first points appearing from the second to the third month in the first three sacral vertebræ, from the fifth to the sixth month in the fourth and fifth vertebræ; the laminæ begin to ossify in the interval between the sixth and ninth month: the first vertebra of the coccyx usually begins to ossify during the first year after birth; the second from the fifth to the tenth; the third from the tenth to the fifteenth; and the fourth from the fifteenth to the twentieth year.

The union of the osseous points takes place at different times; the osseous pieces of each vertebra are first joined together, and subsequently the vertebræ themselves.

1. *Union of the osseous nuclei of each vertebra.* The osseous points of the laminæ are first united; these then join with the anterior lateral nuclei of the first three vertebræ: at a much later period the lateral masses become connected with the body.

The union of the lateral masses with the body takes place much earlier in the fourth and fifth sacral vertebræ, than in the three others, though these latter first showed osseous points. After the union of the lateral masses, the sacrum is composed of five pieces, which remain separate until the fifteenth year.

2. *Union of the sacral vertebræ with one another.* This process commences between the fifteenth and eighteenth year, at which time the epiphysary laminæ of the bodies of the sacral vertebræ are developed. At the age of twenty-five the epiphysary laminæ of the iliac surface of the sacrum are developed. The union commences with the lower vertebræ, and proceeds upwards. The first is not completely joined to the others until from the twenty-fifth to the thirtieth year.

The union of the body of each vertebra with its epiphysary laminæ proceeds from the circumference to the centre, so that in a vertical section of a sacrum, which is completely ossified externally, we often find an intermediate lamina of cartilage. I have observed this cartilage between the first and second sacral vertebræ in subjects of a very advanced age.

The union of the pieces of the coccyx takes place sooner than those of the sacrum. It commences with the first two pieces; the third and fourth then follow; and, in the last place, the second and third are united. Towards the fortieth or fiftieth, or sometimes the sixtieth year, the coccyx becomes united to the sacrum. This junction is later in the female than in the male; sometimes it never takes place.

Development of the spine in general. Up to the end of the first month of conception, the length of the spine is commensurate with that of the body, the extremities as yet only existing under the form of small tubercles. This disproportion between the spine and members is gradually effaced by the elongation of the limbs, so that at birth the vertebral column does not constitute more than $\frac{3}{8}$ths of the height of the subject. In the adult it forms only $\frac{3}{8}$ths.

All the parts which concur in forming the canal for the defence of the spinal cord, are developed prior to those which are specially devoted to locomotion, as is shown in the development of the laminæ, as compared with that of the body and processes. The ossification of the laminæ proceeds in regular succession from above downwards, from the neck to the sacro-coccygeal region. The ossification of the bodies takes a different course, commencing in the dorsal region as a centre, and proceeding to either extremity of the column. The ossification of the bodies of the vertebræ commences in the centre of the bone; and accordingly, if the spine of a fœtus be dried, the cartilages shrink, and the series of osseous nodules which represent the bodies of the vertebræ, look like grains of Indian corn strung together.

In the first periods of its development, the spinal column presents the following remarkable differences from its subsequent condition. It is completely devoid of curvature, and instead of resembling in shape a pyramid with the base below, it is precisely the reverse, the base of the pyramid being uppermost. As the child grows up, the spine gradually acquires those characters which it presents in the adult. In the old subject it is always more or less bent forwards. It is not uncommon to meet with several dorsal or lumbar vertebræ more or less completely united by a layer of bone, which forms a sort of sheath or clasp. To this I have applied the name of anchylosis by invagination.

THE SKULL.

Composed of the cranium and face.— Cranial bones.— Occipital. — Frontal.— Sphenoid. — Œthmoid. — Parietal. —Temporal. — The cranium in general. — Development. — Bones of the face.— Superior maxillary.—Palate.— Malar. —Nasal—Lachrymal.—Inferior turbinated.— Vomer.—Inferior maxillary.— The face in general.— Cavities. — Development.

The skull is the most complicated portion of the skeleton. It has been more minutely investigated than any other part, probably on account of the difficulty of the study. It is composed of two distinct portions: one, *the cranium*, de-

signed to enclose and protect the brain; the other *the face*, which affords lodgment to almost all the organs of the senses, and at the same time is employed in the function of mastication.

The Cranium.

The cranium (κράνος, a helmet) is a round osseous case, composed of eight bones, that is, of eight pieces, distinct and separable after the complete development of the skeleton. Four of these are single, and placed on the median line; viz. (counting from behind forwards), the *occipital*, the *sphenoid*, the *ethmoid*, and the *frontal*: the remaining four are in pairs, and are situated laterally; viz. the two *parietal* and *the two temporal*. To these must be added the small supernumerary bones, denominated *ossa wormiana, or triquetra*.

The Occipital Bone (figs. 9. *and* 10.).

The occipital bone occupies the posterior, inferior, and middle portion of the cranium, a great part of the base of which it constitutes.* Below it is articulated with the vertebral column; in front with the sphenoid; and it is, as it were, wedged in between the parietal and temporal bones of the right and left sides. It is broad and symmetrical; in shape an irregular segment of a spheroid, notched round the circumference. It has *an anterior* and a *posterior surface*, and a *circumference*, having *four borders* and *four angles*.

The *posterior or cutaneous surface* (*fig.* 9.) is convex, and presents the *inferior orifice of the occipital foramen*, (1, *fig.* 9.; *d*, *fig.* 21.) (foramen magnum), the largest of all the foramina in the skeleton, excepting the *sub-pubic*, or *obturator foramen* of the os innominatum. It gives passage to the spinal marrow with its envelopes, the spinal accessory nerves, and vertebral arteries. In front of the foramen is the inferior surface of the basilar process (2, *fig.* 9.; *n*, *fig.* 21.) which forms the bony roof of the pharynx; it is placed horizontally, is rough, and has a ridge in the median line more or less prominent in different subjects. Behind the foramen, and in the median line, is the *external occipital ridge* (*perpendicular spine*) (3 4, *fig.* 9.; *c a*, *fig.* 21.), extending from the posterior edge of the foramen to the *external occipital protuberance*. This projection is wanting in some individuals, and in others its place is occupied by a depression. On each side of the ridge are unequal surfaces bounded above by a line with the concavity looking downwards. Thus, the *superior semicircular line* (5 5, *fig.* 9.; *a b*, *fig.* 21.), commences at the occipital protuberance (4, *fig.* 9.; *a*, *fig.* 20.) and proceeds horizontally outwards. The irregular surface included between this line and the foramen, is again divided by a line whose concavity is directed upwards (6 6, *fig.* 9.), and which is called the *inferior semicircular line*.

Fig. 9.

On each side of the occipital foramen, and towards the fore part, are the *condyles* (7 7, *fig.* 9.; *e*, *fig.* 21.), two articular eminences, convex, elliptical, directed from behind forwards, and from without inwards, their surfaces looking downwards and somewhat outwards. They articulate with the atlas. Behind these are two fossæ: the *posterior condyloid*, which are often perforated by an aperture; the *posterior condyloid foramen* (8, *figs.* 9. and 21.), giving passage to a vein. In front, and external to the condyles, are the *anterior condyloid fossæ*, and *foramina* (9 9, *fig.* 9.); the latter are really flexuous canals, through which the hypoglossal nerves pass out of the skull. External to the condyles is a

* It is the *os proræ* of Fabricius of Aquapendente, who, following out the same metaphor, has given the name of *os puppis* to the frontal, and *os carinæ* to the sphenoid.

rough surface, the *jugular surface* (*i*, *fig.* 21.), which gives attachment to the *recti laterales* muscles of the head.

The *internal or encephalic surface* (*fig.* 10.), in common with all the other bones of the cranium, is lined by the dura mater. It presents, 1. *The internal orifice of the occipital foramen* (1, *fig.* 10.), which is larger than the external. 2. Before the foramen the *basilar groove* (2), sloping gently from above downwards and backwards: the sides of the groove are marked by other very small grooves, which concur in forming the *inferior petrosal groove.* 3. On each side the occipital foramen, and towards the fore part, is a projection (3 3) which corresponds with the condyle, and particularly with the anterior condyloid canal. 4. A little more external and posterior is a small portion of a groove (4), which contributes to form the termination of the lateral sinus. 5. Behind the foramen are the four *occipital fossæ*, two *superior or cerebral* (5 5), and two *inferior or cerebellar* (6 6), separated from each other by a crucial ridge. The vertical branch of this ridge (*g a*) joins the termination of the sagittal groove above; below it is formed by the *internal occipital crest* (7). The horizontal branches (*g b*) correspond with the grooves for the *lateral sinuses of the dura mater.* The *internal occipital protuberance* (*g*) is situated at the confluence of the four branches. The right and left lateral grooves are rarely of the same size and depth; the right is generally the larger, and forms by itself the continuation of the sagittal or longitudinal groove.

Fig. 10.

The *circumference* presents four borders and four angles. *The superior* or *parietal borders* (*a b*, *a b*), which are remarkable for the length of their indentations, articulate with the posterior borders of the parietal bones forming the lambdoidal suture.

The *inferior or temporal borders* (*b c*, *b c*) are divided into two equal portions by the *jugular eminence* (*d*), which articulates with the temporal bone. The part (*b d*) above this eminence is slightly denticulated, and united to the mastoid portion of the temporal bone; the part (*d c*) below is thick, sinuous, but without indentations, and articulates by juxta-position with the petrous portion of the temporal. In front of the jugular eminence is a deep notch, sometimes divided into two parts by a process of bone, which contributes to form the posterior lacerated foramen.

The *superior angle* (*a*) is acute, and is received into the retreating angle, formed by the posterior borders of the parietal bones. Its place is sometimes supplied by a Wormian bone. In the young subject the *posterior fontanelle* is placed here. The *inferior angle* (*c*) is truncated and very thick; it forms *the basilar process*, which presents a rough articular surface for union with the body of the sphenoid. The connexion is established by means of a cartilage, which becomes ossified at a very early period, so that many anatomists describe the sphenoid and occipital as one bone.*

The *lateral angles* (*b b*) are very obtuse, and are received into the retiring angle formed by the union of the parietal with the temporal bone. At these angles the *lateral and posterior fontanelles* are situated.

Connexions. The occipital articulates with six bones — the two parietal, the two temporal, the sphenoid, and the atlas.

Structure. The part of this bone which forms the occipital fossæ consists almost exclusively of compact tissue. It is here extremely thin, especially at

* A reference to Comparative Anatomy would seem to justify this view, for in some inferior animals the basilar process and the sphenoid are but one piece.

the inferior fossæ. In the rest of its extent there is spongy tissue between the two tables. The external table is much thicker and less brittle than the internal, which is named *vitreous* on account of its fragility. The spongy tissue is very abundant in the condyles and in the basilar process.

Development. The occipital bone is developed from four points—one for the squamous portion, that is, the part of the bone behind the foramen magnum; one for each lateral condyloid portion of the occipital, and one for the anterior or basilar portion. These four parts are considered by some anatomists as so many distinct bones, which they describe under the names of posterior or superior occipital, lateral occipitals, and anterior occipital or basilar bone. The first point of ossification appears in the squamous or back part of the bone, under the form of a small oblong plate placed transversely in the situation of the protuberances. I have never seen this piece formed by two lateral points. The part of the bone of which we are speaking is always visible towards the middle of the second month. The condyloid portions make their appearance next, and lastly the basilar portion, which I have never seen developed from two lateral points. In a fœtus of two months and a half, the ossified part of this process presented the appearance of a linear streak, situated exactly in the median line, and directed from before backwards. The four points of ossification are finally united at the foramen magnum.

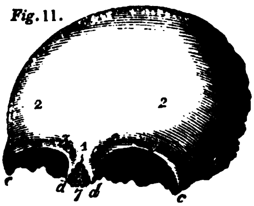
Anatomists, however, are not at all agreed respecting the number of points of ossification. Meckel admits eight for the posterior part of the bone, two for the condyles, and one for the basilar process. Béclard, on the other hand, admits only four in the posterior part of the bone. His opinion is founded upon the existence of four fissures or divisions at the circumference of this portion; viz. one at the superior angle, which sometimes gives to the posterior fontanelle the lozenge shape of the anterior; one below, which is nothing more than a slight notch in the back of the foramen magnum; and two on each side, corresponding to the posterior lateral fontanelles. The opinion of Meckel is perhaps grounded upon certain abnormal cases, in which this part of the bone is divided into a considerable number of pieces resembling so many Wormian bones united by suture.

The Frontal or Coronal Bone (*figs*. 11 and 12.).

The frontal bone is situated at the anterior part of the skull, and above the face. It is symmetrical, and represents a considerable segment of a hollow sphere. From its shape it has been compared to a shell. The superior three fourths are curved, placed vertically, but more or less inclined from above downwards and forwards; the inferior fourth is flat and horizontal. It has an anterior, a posterior, and an inferior surface, and three borders.

The *anterior cutaneous or frontal surface* is smooth and convex; there is a suture in the median line in young subjects, which in the adult is obliterated, leaving scarcely any trace of its existence, excepting at its termination below. At this spot there is a prominence named *nasal eminence* or *glabella* (or middle frontal eminence) (1, *fig*. 11.).

Fig. 11.



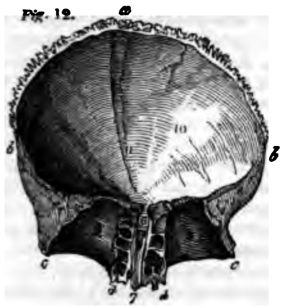
On the sides of the median line proceeding from above downwards we observe two smooth surfaces; then the *frontal eminences* (2 2), two projections which are most strongly developed in young subjects; and below these on each side of the glabella, the *superciliary ridge*, an arched elevation which forms the margin of the orbit, and is more prominent towards the nose than externally. Quite at the outside of the anterior surface of the frontal, there is a small depressed, triangular surface (4), which looks directly outwards, and is separated from the

frontal eminence by a sort of *crest* running upwards and backwards (5): it forms the anterior part of the temporal fossa.

The anterior surface of the frontal bone is separated from the skin by the frontal, orbicular, and corrugator supercilii muscles, and the anterior portion of the cranial aponeurosis.

The *inferior or orbito-ethmoidal surface* (*fig.* 12.) presents in the middle a large rectangular notch (6), which extends the whole length of this surface from before backwards. This notch, which is named *ethmoidal*, because it receives the ethmoid bone, has, 1. In front, and in the median line, a prolongation, denominated the *nasal spine* (7): this spine is rough in front for articulation with the proper nasal bones: behind it is marked by two grooves, separated by a vertical ridge; the ridge joins the perpendicular lamella of the ethmoid, and the two grooves form part of the vault of the nasal fossæ. 2. Farther back and on each side is the large opening of the frontal sinuses. 3. The two borders of the notch are marked with (*b d*, *b d*) incomplete cells, which join with those of the ethmoid. 4. On the same borders there are two or sometimes three small grooves, which contribute to form the *anterior and posterior internal orbitary canals*.

Fig. 12.



On each side of the notch is the *orbital plate* (9 9), triangular and concave, especially towards the external margin, where there is an excavation for the lachrymal gland (*fossæ glandulæ lachrymalis*). At the internal margin there is a small depression for the attachment of the cartilaginous pulley, in which the tendon of the superior oblique muscle of the eye is reflected.

The *posterior or cerebral surface* is concave, and marked by eminences and depressions corresponding to the sulci and convolutions of the brain, and by furrows for arterial branches. In the median line is a *longitudinal groove*, the sides of which unite below, and form the *frontal ridge*, which terminates in a foramen, called *foramen cæcum*. The ridge is sometimes absent, and occasionally the place of the foramen is occupied by a notch, completed by the ethmoid, as already described. On each side of the median line are the *frontal fossæ*, which are deeper than the corresponding eminences on the outside seem to indicate: below are the *orbital prominences*, which look directly upwards, *and form a retiring angle** with the frontal fossæ; they are covered with acuminated eminences, which are received into the anfractuosities of the brain.

The *superior or parietal border* (*b a b*) is semicircular, denticulated, and cut obliquely at the expense of its internal plate above, and of its external below, and at the sides. In the middle, it forms a very obtuse angle (*a*), which is received into the retiring angle formed by the parietal bones. In young subjects this angle is wanting; in its situation the anterior angle of the anterior fontanelle is placed.

The *inferior or sphenoidal border* (*b b b*) is very short, thin, and straight, interrupted by the ethmoidal notch, and adapted to the smaller wings of the sphenoid. It terminates externally, at its junction with the superior border, by two triangular surfaces slightly indented, which articulate with the greater wings of the sphenoid.

The *anterior or orbito-nasal border* (*c c*, *fig.* 11.) presents in the centre the *nasal notch* (*d d*), articulated in the middle with the nasal bones, and at the sides with the ascending processes of the superior maxillæ. At the bottom of

* This retiring angle measures pretty exactly the facial angle.

this notch is the anterior surface of the nasal spine. On each side we observe the *orbital arch* (*c d*), more sharp and thin towards its outer end. At the junction of the internal with the two external thirds of this arch, is situated a foramen (*e*), or more frequently a notch converted into a foramen by a ligament; it is called the *superciliary* or *supraorbital foramen*, and gives passage to the frontal vessels and nerves. At the bottom of this notch there are generally one or more vascular openings, which lead into the diploe, and are the terminations of venous canals, which run for a considerable way within the bone. The orbital arch terminates on each side by a process; the inner one, *internal orbital process* (*d*), is broad and thin, and articulates with the os unguis; *the external* (*c*) is thick, and unites with the malar bone.

Connexions. The frontal is articulated with twelve bones—the two parietal, the sphenoid, the ethmoid, the two nasal, and two malar bones, the ossa unguis, and the two superior maxillary.

Internal structure. The vertical portion and external orbital processes are very thick; the horizontal part is very thin, and hence the facility with which instruments can penetrate the cranium through the roof of the orbit. It contains large cavities, *frontal sinuses* (*a, figs.* 23 and 24.), which open in the ethmoidal notch, and add greatly to the thickness of the bone at its lower part. They are separated by a septum, which is often bent to one side, and is generally imperfect. The capacity of these sinuses is very variable; they often extend throughout the whole of the orbital plates, almost to the edge of the sphenoid. The study of these sinuses, which are connected with the organ of smelling, is of great importance in determining the facial angle.

Development. The frontal bone is developed from two lateral points of ossification, which appear about the middle of the second month, and commence in the orbital arches. At this time the edges are in approximation below, but above are separated by an angular interval, which forms the anterior angle of the anterior fontanelle. The two pieces are united by suture during the first year; it is gradually effaced afterwards, being longest visible at its inferior termination, though it is uncommon to find it permanent through life. Independently of these general changes, which the bone undergoes in the course of its development, there are also certain peculiar alterations in which the sinuses are concerned. These cavities make their appearance during the first year, and gradually increase in size, not only up to the period of manhood, but even to old age.

The Sphenoid Bone (*figs.* 13 and 14.).

This bone has received its name from the Greek word σφὴν (a wedge), because it is inserted like a wedge between the other bones. It is situated at the anterior and middle part of the base of the cranium (*fig.* 23.). Almost all anatomists agree in considering it as a separate bone; but Soemmering and Meckel describe it as united with the occipital, under the name of *basilar* or *spheno-occipital bone.* It is a single and symmetrical bone, consisting of a *body* or central part, from which spring, on each side, two horizontal portions, *the greater and lesser wings of the sphenoid;* and below two vertical columns, *the pterygoid processes.* It has been compared to a bat with extended wings. We shall consider it as divided into a body and lateral parts.

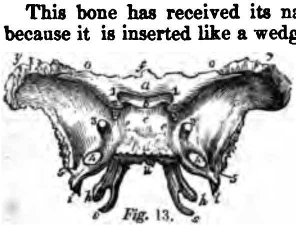


Fig. 13.

The *body*, or *central part*, is of a cubical form, and therefore presents six surfaces.

Superior or *cerebral surface* (*o f o d, fig.* 13.). Proceeding from before backwards, we observe, 1. A smooth plane surface (*a*), slightly depressed on each

side, over which the olfactory nerves pass. 2. A transverse groove, *optic groove* (*b*), on which the commissure of the optic nerves rests, and which is continuous on each side with the optic foramen (1 1).* 3. A deep quadrilateral fossa (*c*), in which the pituitary gland is lodged, called the *sella turcica, supra-sphenoidal,* or *pituitary fossa.* 4. On the sides of this fossa two grooves, named *cavernous* or *carotid grooves,* because they correspond to the carotid arteries and cavernous sinuses. Anteriorly the cavernous groove gives attachment to the ligament of Zinn, a tendon which gives origin to three muscles of the eye. Near its anterior termination, and between it and the pituitary fossa, is the *middle clinoid process* †, generally nothing more than a simple tubercle, but sometimes sufficiently developed to unite either with the anterior or with the posterior clinoid processes, the former case being the more common. 5. Behind the pituitary fossa we observe a *quadrilateral plate* (*d*), directed obliquely from above downwards and backwards; its anterior surface forms part of the fossa, its posterior surface is continuous with the basilar groove, its lateral edges are notched for the sixth pair of nerves, and the superior border which separates the basilar groove and the pituitary fossa, presents, at each extremity, an angular process (*e*), the *posterior clinoid* (from κλίνη, a bed, from a supposed resemblance of the anterior and posterior clinoid processes to the four corners of a bed). 6. From the lateral and anterior parts of the body of the sphenoid arise two triangular processes (*n o, n o*), flattened above and below, extremely thin and fragile, and directed transversely: these are denominated the *orbital* or *lesser wings* of the sphenoid (*alæ minores*), or the *wings of Ingrassius,* from the anatomist who first gave a good description of them. The superior surface of these processes is flat, and corresponds to the anterior lobes of the brain; the inferior surface forms part of the roof of the orbits; the anterior edge is bevilled below, and rests upon the posterior border of the frontal and the ethmoid; the posterior edge is thin and sharp externally, thicker internally, and divides the anterior and middle fossæ of the base of the cranium; the summit (*o*) is pointed, and hence the processes are sometimes called *ensiform* or *xiphoid;* the base presents the internal orifice of the *optic canal* or *foramen* (1), which is directed outwards and forwards, and gives passage to the optic nerve and the ophthalmic artery. The base of the lesser wing terminates behind in a projecting angle (*n*), which forms the *anterior clinoid process;* and behind this is a deep notch, sometimes a foramen, for the carotid artery. Occasionally the anterior are united to the posterior clinoid processes by a long bridge of bone.

All the part of the sphenoid in front of the sella turcica, including the smaller wings, forms the *anterior sphenoid* of some modern anatomists; the remaining portion of the bone constitutes the *posterior sphenoid.* The separation of these two parts, which is but temporary in man, existing only during the early months of fœtal life, is permanent in quadrupeds.

The *inferior* or *guttural surface* of the body (*fig.* 14.) presents, in the median line, a ridge or crest, called the *beak of the sphenoid* or *rostrum* (*g*); it is more prominent anteriorly than posteriorly, is received into a groove of the vomer, and is continuous with the anterior ridge of the body of the bone. On each side is a *deep furrow* concealed by a lamella (on each side of *g*), under which the edges of the vomer are insinuated. At the bottom of this furrow is seen the orifice of a temporary canal, which exists only in young subjects,

Fig. 14.

* [The groove is formed on an eminence named the *olivary process.*]

† When the middle clinoid processes are united with the posterior, they are then also joined to the anterior.

and which, passing obliquely through the sides of the bone, opens in the sphenoidal fissure. This canal is the trace of the still incomplete union of the anterior and posterior sphenoid; it disappears as soon as the sinuses within the bone are developed. More externally, and on the same surface, is situated a small groove running from before backwards, which forms part of the *pterygo-palatine* canal, along which an artery of the same name passes. Still more externally are the *pterygoid-processes* (6 *m h*) (πτέρυξ, *ala*), two large projections directed perpendicularly downwards. In front their surface is broad above, where it forms part of the pterygo-maxillary fossa, and rough below for articulation with the palate bone. Behind is a deep fossa, into which the internal pterygoid muscle is inserted: it is named the *pterygoid fossa*, and is formed by two laminæ, named the *external* and *internal pterygoid plates*, of which the *external* (*h*) is the broader, and the *internal* (*m*) the longer. At the upper part of the internal plate is an elliptical depression called the *scaphoid fossa*, which gives attachment to the *circumflexus palati* muscle. The internal surface of the pterygoid process contributes to form the external wall, and posterior opening of the nasal fossæ (*h i*, *fig.* 25.). The outer surface of the external plate is broad, forms part of the zygomatic fossa, and gives attachment to the external pterygoid muscle. The base of the pterygoid process is pierced from before backwards by the *vidian* or *pterygoid canal* (6 6, *fig.* 14.): its summit is deeply bifurcated to receive the tuberosity of the palate bone. The internal branch of this bifurcation (internal pterygoid plate) is very delicate, and is curved into a hook-like process (*s*) (*hamular process*), round which is reflected the tendon of the *circumflexus* or *tensor palati* muscle.

The *anterior* or *ethmoidal surface* of the body of the sphenoid presents, 1. above and in the median line, a small horizontal projecting angle (*f*, *figs.* 13 and 14.), which articulates with the posterior border of the cribriform plate of the ethmoid: 2. below this, a vertical ridge (*f g*, *fig.* 14.) continuous with the septum of the sphenoidal sinuses, and articulating with the perpendicular lamella of the ethmoid: 3. on each side, the openings of the sphenoidal sinuses (7 7). These are two in number; they are separated from each other by a septum, which inclines sometimes to the right side, sometimes to the left, and are subdivided into a number of irregular cells. They are wanting in the young subject, but acquire a great size in the adult, occupying the whole body of the sphenoid, and extending into the base of the lesser wings, and even occasionally into the substance of the palate bone. External to the irregular orifice of the sphenoidal sinuses, is a rough surface which articulates above with the lateral masses of the ethmoid, and below with the palate bone. The orifice of the sinus is in a great measure closed by a lamina of very variable shape, curved upon itself, and designated *sphenoidal turbinated*, or *triangular bone* (*cornu sphenoidale, ossiculum Bertini*) (*t t*, and *figs.* 15 and 16. *c c*). This plate, which remains separate for some time, appears as if it arose from the upper part of the palate bone, and formed the anterior and part of the inferior wall of the sinus. It is not unusual to find it united either to the palate bone or to the ethmoid.

The *posterior* or *occipital surface* (*x*, *fig.* 13.) is quadrilateral, rugged, and irregular; it articulates with a corresponding surface on the basilar process of the occipital bone, by means of a cartilage, which is very early ossified. On the posterior aspect of the bone, is situated the posterior orifice of the vidian canal.

The *lateral surfaces* of the body of the sphenoid pass into the base of the *great wings*, which we shall next describe.

Great or temporal wings (*y z*). This portion of the bone consists of two large triangular prolongations, on which there are three surfaces: a *superior*, an *anterior*, and an *inferior*; two borders, an *external* and an *internal*; and two extremities, an *anterior* and a *posterior*.

Superior or cerebral surface (*y* 2 *z*). This surface, which forms part of

the middle fossa of the base of the cranium, is concave, quadrilateral, and marked by cerebral impressions and vascular furrows. Towards its inner part, and proceeding from before backwards, we observe, 1. the *superior maxillary foramen* (3), or *foramen rotundum*, directed obliquely forwards and outwards, which gives passage to the superior maxillary nerve; 2. the *inferior maxillary foramen*, or *foramen ovale* (4), which perforates the bone directly from above downwards, and transmits the inferior maxillary nerve; 3. the *foramen spinosum*, or *spheno-spinosum* (5), which is the smallest of the whole, and gives passage to the middle meningeal artery.

External or temporo-zygomatic surface. This surface is divided into two parts by a transverse ridge; the superior or temporal (*l*, *fig.* 14.) forms part of the fossa of the same name, and gives attachment to the temporal muscle; the inferior (*p*) forms the upper part of the zygomatic fossa, and gives attachment to the external pterygoid muscle. On this last part we perceive the inferior orifices of the oval and spinous foramina.

Anterior or orbital surface. This surface (*w w*) is four-sided and smooth, and forms the greater part of the external wall of the orbit. Its superior border unites with the frontal bone; the inferior forms part of the *spheno-maxillary fissure.* The internal border contributes to form the *sphenoidal fissure*, and has a small tubercle near its inner termination. The external joins the malar bone.

Internal border. This border is convex, and commences in front by a triangular and very rough surface (*y y*, *fig.* 13.), which articulates with a corresponding surface on the frontal bone; it then forms part of the *sphenoidal fissure* (2), and finally bends outwards to join the petrous portion of the temporal bone; in this place it is grooved for the lodgment of the cartilaginous portion of the Eustachian tube. The sphenoidal fissure, or *foramen lacerum superius* (2 2, *figs.* 13 and 14.), partly formed in the way we have described, is completed by the lesser wing of the sphenoid. Wide at its internal extremity, it becomes narrow at its outer end, where it is closed by the frontal bone at *o*. It gives passage to the third, fourth, the ophthalmic branch of the fifth, and the sixth pair of nerves, to the ophthalmic vein, and to a prolongation of the dura mater. At the internal extremity of the fissure, there is a furrow, which is occasionally converted into a foramen for the passage of a recurrent branch of the ophthalmic artery, which goes to the dura mater.

The *external border* is concave, bevilled on the outside superiorly and on the inside inferiorly, for articulation with the temporal bone.

The *anterior extremity* is very thin (behind *y*, *fig.* 13.) and bevilled on the inner side for articulation with the anterior and inferior angle of the parietal.

The *posterior extremity* presents a vertical process (*z*), the *spine* or *spinous process* of the sphenoid, which is received into the angle formed by the union of the squamous and petrous portions of the temporal bone, and gives attachment to the internal lateral ligament of the inferior maxilla, and the external or anterior muscle of the malleus.

Connections. The sphenoid articulates with all the bones of the cranium, and with the palatine, vomer, and malar bones of the face.

Structure. The most remarkable circumstance in the structure of the sphenoid, is the presence of the sinuses, which convert the body of the bone into two or more cells (5, *fig.* 22.). The compact tissue prevails in the lesser and the greater wings, and in the pterygoid processes, the thick part only of these containing spongy substance.

Development. In the fœtus, as we have already mentioned, the sphenoid is divided into two quite distinct parts:—1. An anterior sphenoid, consisting of the lesser wings and the portion of the body which supports them; and, 2. A posterior sphenoid, formed of the great wings and the part of the body which corresponds to the sella turcica.

1. The anterior sphenoid is developed from four points of ossification; two for the body, and two for the alæ minores.*

2. The posterior sphenoid is also developed from four points; two for the body, and two for the great wings.

Besides these eight points, there are two others on each side; one for the internal plate of the pterygoid process, and one for the sphenoidal turbinated bone; so that the whole number of centres of ossification of the sphenoid is twelve.

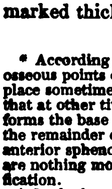
The osseous points of the great wings are the first to appear: they are visible from the fortieth to the forty-fifth day; a short time afterwards, those of the lesser wings, which are situated on the outside of the optic foramen. At the end of the second month the osseous points of the body of the posterior sphenoid are distinct; at the end of the third month, those of the body of the anterior sphenoid, and the internal pterygoid plates: the sphenoidal turbinated bones begin to ossify, according to Béclard, in the seventh month of intra-uterine life; according to Bertin, in the second year after birth.

The two points of the body of the posterior sphenoid are united from the third to the fourth month; the great wings are joined to the body in the course of five or six months after birth. The two points of the body of the anterior sphenoid are joined to those of the small wings about the third or fourth month; they then unite together in the median plane from about the eighth to the ninth month. The union of the internal pterygoid plates takes place during the sixth month.† The anterior and posterior sphenoid are united from the eighth to the ninth month. The sphenoidal turbinated bones are not joined to the body of the bone until from the fifteenth to the eighteenth year. The other changes which the sphenoid afterwards undergoes, are connected with the development of the sinuses. It is united with the occipital bone from the eighteenth to the twenty-fifth year.

The Ethmoid Bone (*figs.* 15 and 16.).

The ethmoid is so named from the Greek word ἠθμὸς, a sieve, because it is perforated with a number of foramina: it is placed in the anterior and middle part of the base of the cranium, but belongs rather to the face and nasal fossæ. It is included between the median notch of the orbital part of the frontal and the sphenoid. It is a symmetrical bone of a cuboidal figure, consisting of three parts — *a middle part* or *cribriform plate*, and two *lateral masses*.

Fig. 15.



Cribriform plate. This is a lamina situated on the median line, horizontal, quadrilateral, and pierced with numerous foramina. It has two surfaces, and two borders. On the *superior surface* (*a a*, *fig.* 15.) we observe in the middle, a vertical triangular process, the *crista galli* (*b* and *n*, *fig.* 22.): the summit of this eminence gives attachment to the falx cerebri; the anterior border terminates in front in two small processes (*alæ*) (*f*), which articulate with the frontal bone, and often complete the foramen cæcum; the posterior border is very oblique, and, is continued to the posterior edge of the cribriform plate, by a marked thickening. There are many variations in the size and direction of this

* According to Albinus, the anterior sphenoid is formed exclusively by the union of the osseous points of the lesser wings in the median line. Béclard observes that the process takes place sometimes as described by Albinus, but that occasionally there is a median point; and that at other times there are two points for each of the smaller wings, the internal of which forms the base of the process, and the inner half of the optic foramen; and the external forms the remainder of the wing. These are the two points which I conceive to form the body of the anterior sphenoid. The very numerous osseous points which some anatomists have described, are nothing more than irregular grains, which have been mistaken for constant centres of ossification.

† In the lower animals the two sphenoid bones remain separate during the whole of life. The inner plate of the pterygoid process is also a distinct bone.

process: it is frequently deflected to one side.* On each side is the *ethmoidal groove* (*a*), deeper and narrower in front than behind: it is pierced throughout its whole extent with numerous foramina, which have been very accurately described by Scarpa, and which form two rows; the internal, situated along the base of the crista galli, being the largest. They all transmit filaments of the olfactory nerves: they are funnel-shaped, and are the orifices of canals, which subdivide in traversing the cribriform plate, and terminate in grooves either upon the turbinated bones or the perpendicular plate of the ethmoid. Among these openings is one which has the form of a longitudinal fissure by the side of the crista galli, and transmits the *ethmoidal* or *nasal branch of the ophthalmic nerve*.

Fig. 16.

The *inferior surface* of the cribriform plate (*fig.* 16.) forms part of the roof of the nasal fossæ; it presents on the median line a vertical plate (*g g, fig.* 16.), which passes from before backwards, and divides it into two equal parts. This is the *perpendicular plate of the ethmoid*, continuous with the base of the crista galli, quadrilateral, often deflected to one side, and forms part of the septum narium (1, 2, 3, 4, *fig.* 22.): in front, it articulates with the nasal spine of the frontal bone, and with the proper bones of the nose; behind with the anterior crest of the sphenoid; and below, with the vomer, and the cartilage of the septum. The *anterior border* of the cribriform plate articulates with the frontal. The *posterior* is usually notched for the reception of the spine, or process (*f, figs.* 13 *and* 14.), which surmounts the median ridge of the sphenoid.

The *lateral masses* are cuboid in figure, and formed of large irregular cells, which together are named the *labyrinth*. They have six surfaces: in the *superior surface* we observe several imperfect cells (*d d, fig.* 15.), which in the united state are completed and, as it were, roofed in by those we have already described as existing on each side of the ethmoidal notch of the frontal. We find also two or three grooves, which join with similar grooves in the frontal bone, and form the internal orbitary canals. On the *inferior surface* we perceive thin irregularly twisted laminæ, which narrow the opening of the maxillary sinuses. The most considerable of these has received the name of *unciform* or *great process* of the ethmoid: it is a curved plate which arises from the inferior surface of the transverse septa, which close the anterior ethmoidal cells, and is placed between the anterior extremity of the middle turbinated bone, and the *os planum* or *lamina papyracea*, to be afterwards described; it sometimes articulates with the inferior turbinated bone. The *anterior surface* presents half cells, which are covered by the os unguis and the ascending process of the maxillary bone. On the *posterior surface* we see the posterior extremities of the superior and middle turbinated bones, and of the superior and middle meatus, and a convex uneven surface which corresponds with the posterior ethmoidal cells. This surface articulates with the sphenoid above, and with the palate bone below. The *external surface* is formed by a smooth quadrilateral plate (*e, fig.* 15.) placed vertically and very thin, to which the ancients gave the name of *lamina papyracea* or *os planum*. It has an elongated rectangular form, is slightly curved upon itself, and constitutes a great part of the internal wall of the orbit. The superior border articulates with the frontal, and assists in forming the orifice of the internal orbital canals; the inferior articulates with the maxillary and palate bones, the anterior with the os unguis, and the posterior with the sphenoid and palate bones.

The *internal surface* constitutes the greatest part of the external wall of the nasal fossæ: on it we observe, in front, a rough quadrilateral surface marked

* Morgagni mentions the case of an asthmatic subject, in whom the crista galli was so obliquely placed that the ethmoidal groove on one side was very much contracted, and considerably enlarged on the other. There was a much greater number of foramina on one side than on the other.

by grooves and canals, which lodge the ramifications of the olfactory nerve; behind, two thin plates, twisted upon themselves like certain shells: they are the *turbinated* or *spongy bones* of the ethmoid, or *conchæ* of the ethmoid. The superior (*b*, *fig.* 35.) is the smaller, and is sometimes named *concha of Morgagni*; Bertin has seen it double. The inferior (*c*, *fig.* 37.) is larger, and forms the *middle concha*; it articulates by its posterior extremity with the palate bone, and its superior border is continuous with a transverse septum, which stretches across to the lower edge of the os planum, and partially closes the middle or frontal cells. The superior and middle turbinated bones are separated by a horizontal groove called the *superior meatus* of the nasal fossæ (between *b* and *c*, *fig.* 37.), at the superior part of which appears an opening of communication with the posterior ethmoidal cells. Below the middle turbinated bone is a similar groove (between *c* and *d*, *fig.* 37.) running from before backwards, and forming part of the *middle meatus* of the nose. Anteriorly it leads into a cell, the lower part of which is broad and the upper narrow, whence it has received the name of *infundibulum*. This cell communicates directly with the frontal sinuses, and by a small aperture with the anterior ethmoidal cells.

Internal structure. The ethmoid is composed of extremely thin and fragile plates arranged in more or less irregular cells, having a hexaedral, pentaedral, or tetraedral shape. They are disposed in distinct series, which have no communication with each other. The anterior cells are the largest and most numerous; they open into the middle meatus by the infundibulum; the posterior open into the superior meatus. There is a little spongy substance in the crista galli, which is even sometimes hollowed into a small sinus which communicates with the frontal sinuses. There is also spongy substance in the turbinated bones, and here, by a remarkable exception, it occupies the surface. The specific lightness of the ethmoid is such that it floats in water, and its extreme brittleness is readily explained by its spongy structure.

Connections. The ethmoid is connected with thirteen bones: the frontal, the sphenoid, the ossa unguis, the superior maxillary, the inferior turbinated, the nasal, the palate bones, and the vomer.

Development. The ossification of the ethmoid does not commence until the fifth month. It begins in the lateral masses, and more particularly in the os planum; shortly afterwards the spongy bones make their appearance. The middle portion is not ossified until after birth. The crista galli and the contiguous part of the perpendicular plate, and the cribriform plate, become bony between the sixth month and the first year. At the end of the first year, the cribriform plate is united to the lateral masses. In the fœtus, at the full time, the lateral masses are so little developed, that their internal and external walls are almost contiguous. The cells are completely formed about the fourth or fifth year.

The Parietal Bones (*figs.* 17 and 18.).

Fig. 17.

The parietal bones are so called, because they form the greatest part of the sides of the head. They are two in number, the right and the left; but sometimes in the adult they are united so as to form only one bone. They occupy the summit and sides of the head. In shape they are quadrilateral, and much thicker above than below, so that a force applied to the crown of the head often causes a fracture of the lower parts of these bones. The parietal bones have two faces, four borders, and four angles.

The *external* or *cutaneous surface* (*fig.* 17.) is convex and smooth, with a

projection in the centre, the *parietal protuberance* (*i*), which is more prominent in the child than in the adult, and corresponds with the point where the breadth of the cranium is greatest. Below this there is a semicircular line (*g*), with the concavity looking downwards, which forms the superior boundary of the temporal fossa, and gives attachment to the temporal muscle. The rest of this surface is covered only by the cranial aponeurosis and the skin.

The *internal* or *encephalic surface* (*fig.* 18.) is concave, and marked with mammillary projections and digital impressions; it is traversed by ramified grooves, resembling the veins of a leaf (*f f, fig.* 18.), which converge partly to the anterior inferior and partly to the posterior inferior angle of the bone, and correspond to the branches of the meningeal artery. The *parietal fossa*, a concavity corresponding to the prominence of the same name, is situated in the middle of this surface.

Fig. 18.

The *superior* or *sagittal border* (*a b fig.* 17 and 18.) is the longest, it is thick and denticulated, and by its union with the opposite bone forms the sagittal suture. On its internal surface there is a furrow along its whole extent, which, with that in the opposite bone, forms the groove for the longitudinal sinus. Near this border is sometimes found a foramen (*c*), (*foramen parietale*), of very variable dimensions, which opens into the posterior part of the groove and transmits a vein.

The *inferior* or *temporal border* (*d e*) is the shortest: it is concave, thin, and very obliquely cut on the outside, so as to resemble a scale with radiated furrows; hence its name (*margo squamosus*): it articulates with the squamous portion of the temporal bone.

The *anterior* or *frontal border* (*b e*) is less thick and less deeply indented than the occipital edge; it is bevilled externally above, and internally below, so as to articulate with the frontal bone, which presents a precisely opposite arrangement.

The *posterior* or *occipital border* (*a d*) is very deeply indented, and articulates with the superior border of the occipital by the lambdoid suture. Of the *four angles*, the two superior are right angles; of the inferior, the *anterior* or *sphenoidal* (*e*) is acute, and rendered very thin by the sloping of the anterior and inferior edges of the bone. Inside this angle is situated the principal furrow, or sometimes canal, which lodges the middle meningeal artery and veins: surgeons therefore recommend this angle to be avoided in performing the operation of trepanning. The *posterior* or *mastoid angle* (*d*) is, as it were, truncated, and is received into the retreating angle formed by the union of the mastoid and squamous portions of the temporal bone. Internally it is grooved for the reception of part of the lateral sinus (*e, fig.* 22.).

Connections. The parietal is articulated with five bones: the frontal, the occipital, the temporal, the sphenoid, and the opposite parietal. Above it is separated from the skin by the cranial aponeurosis only, and consequently it exposes a large extent of surface to the action of external agents: hence fractures of this bone are very common, and they are more frequently than other fractures accompanied by effusions of blood, on account of the connection with the middle meningeal artery and vein.

The *internal structure* is quite similar to that of the frontal. As in that bone, we find venous canals traversing long tracts in the substance of the diploe.

Development. The parietal bone is developed from one point of ossification alone, which appears in the situation of the protuberance. Its first traces are

observed about the forty-fifth day. The angles are the last parts of the bone which are developed: their absence gives rise in part to the six fontanelles of the cranium.

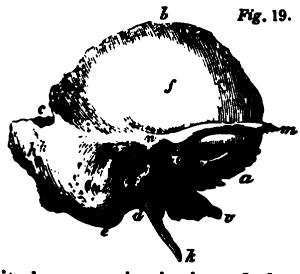
The Temporal Bones (*figs.* 19 and 20.).

The temporal bones are so called from being situated in the locality of the temples. They are two in number, and occupy part of the sides and base of the cranium, below the parietal bones, above the inferior maxillary, in front of the occipital, and behind the sphenoid. The temporal bone contains the complicated apparatus of the organ of hearing.

Its figure is very irregular, and therefore, in order to facilitate the description, we shall consider it as divided into three parts; the *squamous*, the *mastoid* and the *petrous* portions.

Squamous portion. The squamous portion has the form of a semicircular scale (*a b c*, *figs.* 19 and 20.), bearing a considerable resemblance to one of the valves of certain shell-fish: it occupies the anterior and superior part of the bone. It is by far the thinnest part of the cranium; and hence the common but well-founded notion of the danger of blows upon the temple, although this danger is much lessened by the presence of the zygomatic arch and the temporal muscle.

Fig. 19.



The *external surface* (*f*, *fig.* 19.) forms part of the temporal fossa; it is smooth, convex, and marked by vascular furrows. At its lower portion is situated the *zygomatic process* (*m n*) (ζευγνύω, I join), so called because it unites the sides of the cranium to the face: it is also named *ansa capitis*, and is one of the longest processes of the skeleton. At its origin it is broad and directed outwards; it then gradually diminishes in size, and bends so as to turn horizontally forwards and a little outwards: it is flattened from without inwards. The external surface is convex, and may be easily traced under the skin; the internal surface is concave; the superior border convex and thin; the inferior concave, thick, and much shorter; and the extremity (*m*) is cut from below upwards and forwards, and denticulated for attachment with a corresponding surface on the malar bone. The base of this process is grooved above, and serves as a pulley for the reflection of part of the temporal muscle. Posteriorly it separates into two portions or *roots*: the *inferior* (*o*) of these is the larger; it is transverse, covered with cartilage, and bounds the glenoid cavity in front, serving also to increase the articular surface in the joint of the lower jaw. The *superior* (*n*) is longitudinal or antero-posterior in its direction: it also is bifurcated, one branch directed upwards and forming part of the temporal semicircular line, the other passing between the auditory meatus and the glenoid cavity. At the point of junction of the two roots, there is a tubercle which gives insertion to the external lateral ligament of the lower jaw. Between the two roots we observe the *glenoid cavity* (behind *o*), divided into two portions: the anterior of which is articular, smooth, and in the fresh state covered with cartilage; the posterior (*s*) does not enter into the formation of the joint. The parts are separated by a fissure, called *glenoidal fissure* or *fissure of Glasserus* (before *s*), which transmits the corda tympani nerve *, the laxator tympani or external muscle of the malleus, the internal auditory vessels, and lodges the processus gracilis of the malleus (*process of Raw*).

* [The corda tympani, according to the author, passes through a special orifice by the side of the glenoid fissure. See description of the ear, *infrà*.]

The *internal surface* of the squamous portion (*g*, *fig.* 20.) presents a concavity proportionally greater than the convexity on the outside: it is marked by the ordinary inequalities, and is generally traversed towards the upper part by a horizontal vascular furrow, running from before backwards.


Fig. 20.

The *circumference* (*a b c*) forms about three-fourths of a circle: it is very obliquely cut internally in its two posterior thirds, which unite with the parietal: the anterior third is thicker and bevilled externally, it unites with the sphenoid.

Mastoid portion (*c e d*, *figs.* 19 and 20.) The mastoid portion is very prominent in adults, but only slightly developed in young subjects: it occupies the posterior and inferior part of the bone.

The *external surface* (*fig.* 19.) is convex, and rough, terminating below and in front in a nipple-shaped process, the *mastoid process* (*e*). Inside of this is a deep groove called digastric (*fossa digastrica*), because it gives origin to the muscle of that name. Still more internally there is a very small groove, parallel to the last, in which the *trachelo-mastoid* muscle is inserted. Behind the mastoid process we observe the *mastoid foramen*, an opening which transmits the mastoid artery and vein, but which is subject to numerous varieties in its size and position. Above the process is a rough surface, for muscular attachments.

The *internal surface* is concave, and forms part of the lateral and posterior fossæ of the cranium; we observe on this surface a deep and broad semi-cylindrical groove (*h i*, *fig.* 20.), which lodges the greater portion of the lateral sinus. At the bottom of this groove the mastoid foramen opens by one or more apertures. There is generally a considerable difference in size between the grooves on the right and left side of the head.

The *circumference*, very thick and indented, unites in front with the circumference of the squamous portion, forming a retiring angle (*c*), which is occupied by the posterior inferior angle of the parietal bone, and then curves round in a semicircle to join the occipital bone by means of a thick uneven edge.

Petrous portion; Rocher or *pyramid* (*c i d v*, *fig.* 20.) *Petrous process.* This part of the bone is placed between the squamous and the mastoid portion, resembling a pyramid projecting forwards and inwards into the cavity of the cranium. Its name sufficiently indicates the extreme hardness of its osseous structure,—a circumstance very important in relation to its functions (for this part of the bone serves as the receptacle of the vibratory apparatus of the ear), and at the same time calculated to explain the frequency of fractures in this situation. It has the form of a truncated pyramid with three faces, separated by three borders.

The *inferior surface*, which is seen at the base of the cranium, is very irregular, and presents the following objects, in an order from without inwards:— 1. A long, slender process (*k*) generally from twelve to fifteen lines, sometimes two inches in length. This process, which has been denominated *styloid*, is, in man, usually continuous with the rest of the bone, but occasionally it is articulated by a movable joint, as in the lower animals, where it is always separate, and is known by the name of *styloid bone.*

2. Behind this process, between it and the mastoid, is a sort of fossa, at the bottom of which we find, besides one or two accessory foramina, the *stylo-mastoid foramen* (*y*, *fig.* 21.), the inferior aperture of a canal improperly called the *aqueduct of Fallopius**, which transmits the facial nerve. 3. Inside of the styloid process, and the stylo-mastoid foramen, is a triangular surface, called the *ju-*

* [Fallopius knew that this canal transmitted a nerve; he named it *aqueduct* merely on account of its direction.]

gular, which joins with a corresponding part of the occipital bone. 4. A little within and behind the styloid process is a deep depression, which forms part of the *jugular fossa*, and lodges the enlarged commencement or sinus of the jugular vein. 5. The inferior orifice of the *carotid canal* (*v*, *fig.* 21.), which is directed at first vertically, then horizontally, running forwards and inwards, and again vertically at its termination in the cavity of the cranium. 6. A rough surface, which gives attachment to the levator palati muscle, and the internal muscle of the malleus. Lastly, in front of the styloid process is an osseous lamina, in the form of a *vertical crest* (*s*, *fig.* 19.), a continuation of the plate which forms both the inferior portion of the auditory canal, and the posterior portion of the glenoid cavity, which it completes. This crest, which has been described by authors under the name of *vaginal process*, because it surrounds the styloid process without adhering to it, extends inwards to form part of the carotid canal, and outwards to the mastoid process. Between the crest and the mastoid process there is a small fissure, which may with propriety be denominated the *fissure of the auricular twig*, because it transmits the posterior auricular twig which comes off from the facial nerve.

The other two surfaces of the petrous portion, of which one is superior and the other posterior, are in the interior of the cranium.

The *superior surface*, which looks forwards, has a furrow running from before backwards, and from below upwards, terminating about the middle of the surface in a small irregular opening—the *hiatus Fallopii*, which communicates with the *aqueduct of Fallopius*. The furrow and the hiatus contain the superior or cranial filament of the vidian nerve, and a small artery.

The *posterior surface* shows a canal directed obliquely from within outwards and forwards. This is the *internal auditory meatus* (*l*, *fig.* 20.); it is shorter than the external, and is terminated by a lamina divided into two parts by a transverse ridge; in the superior of these parts there is a single orifice, the commencement of the *aqueduct of Fallopius*, which receives the facial nerve; the inferior is perforated by numerous openings, through which the fibres of the auditory nerve pass; it is the cribriform plate of the auditory nerve. Behind the internal auditory meatus is a small opening, which is the orifice of a canal named *aqueductus vestibuli*.

These surfaces of the petrous process are separated by three borders.

On the *superior border* (*m v*) we observe a furrow for the superior petrosal sinus, also a projection which corresponds with the superior semicircular canal of the internal ear, and which is most prominent in the young subject; inside of this projection, a cavity, the depth of which is in the inverse ratio of the age, and is gradually obliterated in the adult, and near the summit a depression, on which the fifth or trifacial nerve rests.

The *anterior* or *sphenoidal border*, in the external half of its extent, is connected with the squamous portion of the bone; at first by a suture which often remains perfect even in adult life, and subsequently in a great measure disappears, but is never completely obliterated. The internal half is free, and forms, by its union with the squamous portion, a retiring angle, at the apex of which are the openings of two canals, placed parallel, like the barrels of a double barrelled gun, and separated by a small osseous lamina. The *superior canal*, much the smaller, contains the internal muscle of the malleus; the *inferior canal* forms the osseous portion of the *Eustachian tube*. They both communicate with the cavity of the tympanum; the bony lamella, which separates them, is called the *cochleariform process*.

The *inferior*, *posterior*, or *occipital border*, rough, but without indentations, is united to the occipital bone by juxta-position. It has a deep notch, which forms part of the *posterior lacerated foramen*. This notch, which is continuous with the jugular fossa already described, is frequently divided into two portions by a tongue of bone,—one being anterior, the other posterior. Immediately in front of the notch is a small triangular opening, — the *inferior orifice* of the *aqueduct of the cochlea*.

On *the base* (*fig.* 19.), which is not distinct from the rest of the bone, the

only part to be noticed is the *external auditory meatus* (*y*), which is situated behind the glenoid cavity. It is rough inferiorly for the insertion of the cartilage of the ear; and the canal, which is more contracted in the middle than at either extremity, takes a curved direction, the concavity looking downwards and forwards: it is chiefly formed by a curved plate, named the *auditory process*, which constitutes the posterior half of the glenoid cavity.

The *summit* of the pars petrosa (*v*, *fig.* 20.) is very irregular, and truncated: it presents the superior orifice of the carotid canal, and forms part of the anterior lacerated foramen.

Connections. The temporal articulates with five bones:—viz. three of the cranium, the parietal, occipital, and sphenoid; and two of the face, the malar and the inferior maxillary: we might add also the os hyoides, which is attached by a ligament to the styloid process.

Internal structure. The squamous portion is compact throughout, excepting towards the circumference, where traces of diploë may be seen. The petrous portion is still more compact and hard, resembling in density the teeth, or certain ivory-like exostoses. The mastoid portion is hollowed out into large cells, and is very liable to be affected by caries. In the description of the *organ of hearing*, we shall notice the cavities which exist in the petrous portion: the nervous and vascular canals will be described with the nerves and vessels which traverse them. (For the aqueduct of Fallopius, see the description of the facial nerve.)

Development. The temporal bone is developed from five points of ossification: the squamous, petrous, and mastoid portions, the auditory canal, and the styloid process, being each distinct. The first osseous point which appears, is situated in the squamous portion, and is visible towards the end of the second month. Immediately afterwards the petrous portion exhibits a bony nucleus, stretching from its base towards its apex. The third point in order is that of the circle of the tympanum, a kind of ring channelled all round for the membrana tympani. This circle, at first almost horizontal, becomes gradually more and more oblique: it is incomplete above, and the two extremities which are applied to the squamous portion, cross each other, instead of uniting. In many animals the ring of the tympanum constitutes a distinct bone, named the *tympanic bone*. The fourth point of ossification appears in the mastoid portion during the fifth month. The last which becomes visible is that of the styloid process: it also remains distinct throughout life in the lower animals, and is called the *styloid bone*. It is not uncommon to find it in the same condition in the human subject.

The development of these five pieces does not advance with equal rapidity. The petrous portion is most quickly completed. The mastoid, squamous, and petrous portions become united during the first year. The styloid process is attached to the rest of the bone at the age of two or three years; at birth the glenoid cavity is almost flat, on account of the absence of the auditory canal, and the slight development of the transverse root of the zygomatic process. The ulterior changes which take place in the temporal bone depend on the completion of the auditory canal and glenoid cavity, the increasing size of the mastoid process, and the obliteration of the projections, and filling up of the hollows on the surface of the petrous portion.

It is worthy of remark, that traces of the union of the base of the petrous portion, with the squamous and mastoid portions, are visible in individuals of the most advanced age.

The Cranium in general.

The different bones which we have described unite in forming the cranium, an osseous cavity which incloses the brain, the cerebellum, and the annular protuberance. It is situated above the face, is the most elevated portion of the skeleton, and forms a continuation of the vertebral column. The form of the cranium is that of an ovoid, flattened below and at the sides, and with the

large extremity turned backwards. It is never perfectly symmetrical; but a very great deviation has always appeared to me coincident with disease. From attentive examination of a great number of skulls of idiots and maniacs, I have observed that in these subjects there is a remarkable difference between the two sides.

The *dimensions* of the cranium have been very accurately determined by Bichât. The antero-posterior diameter, measured from the foramen cæcum to the occipital protuberance, is about five inches*; the transverse diameter, measured between the base of the petrous portions of the temporal bones, is *four inches* and a half; the vertical diameter, extending from the anterior edge of the foramen magnum to the middle of the sagittal suture, is rather less than the transverse. In front, and behind the spot where the height and breadth of the cranium are measured, *i. e.* in front and behind the bases of the petrous bones, the diameters progressively diminish. Hence it follows that the point where the cranium has the greatest capacity, is the junction of the two anterior thirds with the posterior third; that is to say, at the place of meeting, or, if I may use the expression, at the *confluence* of the brain, cerebellum, and spinal marrow.

The cranium, however, presents many varieties, both in regard to its dimensions and shape. The varieties of form of the skull in different individuals appear generally to depend upon the preponderance of one diameter over another; and it may be remarked that in these cases, where one diameter is much increased, the others are almost invariably diminished in the same proportion, so that the absolute difference in size is by no means considerable.

There are also variations in size and figure peculiar to the crania of different nations, as has been shown by the researches of Blumenbach and Sœmmerring. In the white or Caucasian race the cranium is decidedly much larger than in the others, more especially than in the negro. Among certain tribes, the configuration of the cranium is determined by the permanent or frequently repeated compressions to which the skulls of infants are subjected. It varies also according to age and sex, being proportionally larger in the fœtus than in the adult, and in the male than in the female. It should be remarked that all these varieties are exclusively confined to the vault of the cavity. Since the cranium is exactly moulded upon the brain, great interest has been attached to the exact appreciation of its dimensions, and hence the different measurements which have been adopted for this purpose. The oldest is the one proposed by Camper, under the name of the *facial angle*. This angle is intended to measure the relative proportions of the cranium and face. It is taken by drawing one line from the middle incisors of the upper jaw, along the front of the forehead, and another from the same point to the auditory meatus. The angle included between these lines is in the European from 80° to 85°: in the Mongolian race 75°, and in the Negro 70°. This anatomical fact had not escaped the attention of the ancients. We observe that in the statues of their heroes and gods, they have even exaggerated the facial angle, which is generally 90°, and even more in the case of Jupiter Tonans.

The facial angle gives no information respecting the capacity of the posterior regions of the cranium, and consequently Daubenton had this specially in view in his mode of measurement, which bears the name of the *occipital angle of Daubenton*. This, however, like the preceding, and in fact all linear measurements, applied to the determination of the capacity of the skull, is necessarily inexact. The variable thickness of the walls of the cavity, the greater or less development of the sinuses, and the projection of the alveoli, or their obliteration after loss of the teeth, are all important elements in the estimate, which have been entirely neglected: and, moreover, the facial and the occipital angle can only express the dimensions in one direction. The capacity of a cavity, like the volume of a solid, can only be determined by an estimate of its three dimensions. Hence measures of surface and measurements, taken in the interior of

* [An old Paris inch is = 1·065765 inch English.]

the cranium, must be employed for this purpose. This is the object proposed by Cuvier, in comparing the *area of the cranium, and the area of the face*, cut vertically from before backwards.

A section of the cranium represents an oval, with the broad end backwards: a section of the face is triangular. In the European, the area of the cranium equals four times that of the face, without the lower jaw; in the negro the area of the face is increased one fifth. The most general result which can be deduced from a comparison of the cranium and face in man, and in mammalia, is that they are developed in an inverse ratio. One appears to augment at the expense of the other.

Division of the Cranium, and Description of its different Regions.

The cranium considered as one piece, presents *an external surface*, and an *internal* or *encephalic surface*. Many of the objects seen on these surfaces have been already described with the particular bones to which they belong; these we shall merely point out: others which result from the union of the bones in one common whole, will be examined more in detail.

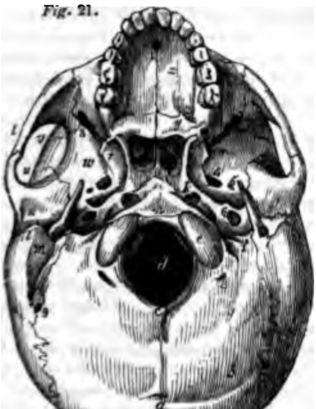
External Surface of the Cranium.

The external surface of the cranium offers, for consideration, a superior region or vault, an inferior, and two lateral regions.

The *superior region* or *vault* is bounded by a circular line, passing from the middle, frontal, or nasal protuberance (*glabella*), along the temporal fossa, to the external occipital protuberance. It is principally covered by the occipito-frontalis muscle, and presents in the median line, 1. the trace of the union of the two primitive halves of the frontal bone: 2. the *bi-parietal* or *sagittal suture* (sagitta, *an arrow*), which forms a right angle in front with the *fronto-parietal* or *coronal* suture, and terminates behind at the superior angle of the *occipito-parietal*, or *lambdoidal* suture (from the Greek letter lambda): 3. behind this suture, a depression corresponding to the anterior superior angle of the occipital bone.

On each side we observe three eminences more or less prominent in different individuals, and always most marked in the young. These are the frontal, the parietal, and the superior occipital protuberances. Between the frontal and parietal protuberances, the *coronal* suture is situated: and between the parietal and the occipital, we find the *lambdoid* suture. Besides these there are a great number of smaller projections, which Gall has also denominated *protuberances*, and to which much importance is attached in his system.

Fig. 21.



The *inferior region* or *base of the cranium* (*fig.* 21.) is flattened and very irregular. It is bounded behind, by the external occipital protuberance (a) and superior semi-circular line (a b); in front, by the glabella or nasal eminence: laterally, by a line passing over the mastoid and external orbital processes. I shall content myself by describing in this place the posterior half of the base of the cranium; the other half will be included in the description of the face, with the bones of which it concurs in forming the orbital, nasal, and zygomatic fossæ. The pterygoid processes below, and the posterior edge of the sphenoid above define the limits of these two *portions*.

The posterior half of the base of the cranium presents, in the *median line* and in an order from behind forwards, the external occipital protuberance (*a*), the external occipital crest (*a c*), the foramen magnum (*d*), and condyles (*e*), the basilar process (*n*), and the transverse suture, which results from the articulation of the body of the sphenoid with the truncated inferior angle of the occipital bone — the *spheno-occipital suture*.

On *each side* we observe the inferior occipital protuberances, presenting certain variations in size in different subjects, to which Gall has attached great importance in his craniological system. These protuberances are bounded above by the superior semicircular line of the occipital bone (*b*); they are crossed in the middle by the inferior semi-circular line (*g*), which is separated from the preceding by muscular impressions. Between the inferior semi-circular line and the occipital foramen, are also a number of inequalities for the attachment of muscular fibres. Still more anteriorly is the posterior condyloid fossa, and occasionally the posterior condyloid foramen (*g*). Outside the condyles are the jugular surface (*i*), the eminence of the same name, and the *petro-occipital suture*, running obliquely from behind forwards and inwards (*i k*), without any indentations, or even complete juxta-position of the bones, and terminating behind in a large irregular opening (before *i*), the *posterior lacerated foramen*, which is divided into two parts by a tongue of bone: the anterior is the smaller, and transmits the eighth pair of nerves; the posterior is larger, and is called the jugular fossa, from its receiving the enlarged commencement (*sinus* or *diverticulum*) of the jugular vein. The petro-occipital suture terminates in front in another irregularly triangular opening, the *anterior lacerated foramen* (*k*), which is closed by cartilage, and forms, in fact, a fontanelle between the edges of the occipital, temporal, and sphenoid bones. In front of the petro-occipital suture is the inferior surface of the petrous bone, with its numerous asperities; then, still proceeding from behind forwards, we find the mastoid process (*l*), the digastric groove (*m*), the stylo-mastoid foramen (7), the styloid and vaginal processes, the inferior orifice of the carotid canal (*v*), and the *petro-sphenoidal* suture, at the external termination of which the osseous portion of the Eustachian tube opens by an orifice directed obliquely forwards and downwards.

Thus all the sutures of the posterior half of the base of the cranium meet in the anterior lacerated foramen. From its internal angle the spheno-occipital suture stretches across to the same part of the opposite foramen. The petro-sphenoidal suture sets out from the external angle, and becomes continuous with the fissure of Glasserus; and the petro-occipital suture extends from the posterior angle to the occipito-mastoid suture, which it joins at an obtuse angle: all these sutures are formed by juxta-position, and not by mutual reception as those of the roof of the skull.

The *lateral regions* of the cranium are bounded behind by the lambdoid suture; in front by the external orbital process; and above by the temporal ridge. This region more or less rounded in different subjects is, nevertheless, the flattest part of the vault of the skull. Proceeding from behind forwards, we observe, 1. the *mastoid region* comprehending the mastoid foramen (9, *fig.* 21.), the external auditory meatus, the glenoid cavity, and the transverse root of the zygomatic process: 2. the *temporal region* or *fossa*, concave in front, convex behind, bounded below by the zygomatic arch, which projects considerably from the head, more especially in carnivorous animals, and by a ridge which separates it from the zygomatic fossa. The temporal fossa is traversed by numerous sutures, arranged in the following manner. The *fronto-parietal* or *coronal suture* (*c b*, *fig.* 22.) descends vertically; from its inferior extremity two others proceed, one in front, the *spheno-frontal*, the other behind, the *spheno-parietal*. Each of these soon divide into two branches. From the spheno-parietal the *spheno-temporal* descends, and terminates in the fissure of Glasserus; the *temporo-parietal* (*b i d*) passes horizontally, and becomes continuous with the lambdoidal suture (*d f*). The spheno-temporal and temporo-parietal sutures are, each, *part of the squamous suture*. From the spheno-frontal suture the two following

proceed; the *fronto-jugal** running horizontally, and the *spheno-jugal* which passes downwards; the denominations of these sutures indicate at once the bones by which they are formed. The explanation which we have given appears the most likely to facilitate the recollection of these numerous sutures, by connecting them with each other. The following table exhibits a summary of all that has been stated.

Fronto-parietal suture	Spheno-parietal	Spheno-temporal Temporo-parietal.
	Spheno-frontal	Fronto-jugal Spheno-jugal.

All these sutures are remarkable from the circumstance, that the bones which enter into their formation, are cut obliquely like scales, and for the most part, the edge of the bone above, is overlapped by the edge of the bone below, so that each inferior scale, like the abutment of an arch, prevents the superior one which corresponds to it, from being forced outwards. (Vide *Mechanism of the Cranium.* SYNDESMOLOGY.)

Internal Surface of the Cranium.

In order to examine the internal surface of the cranium, it is necessary to make two sections, one horizontally from the occipital protuberance to the glabella (*fig.* 23.), the other vertically along the median line from before backwards (*fig.* 22.).

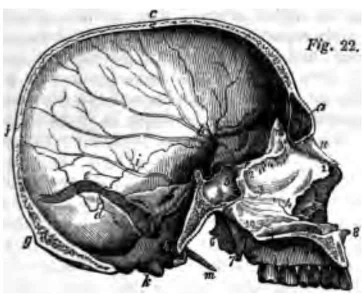


Fig. 22.

In the *median line*, proceeding from before backwards, we observe the frontal crest or ridge, and the *longitudinal groove*, stretching from the frontal crest, along the roof of the skull to the internal occipital protuberance. In this groove, which is of no great depth, we find a line which indicates the place of union of the two pieces of the frontal bone during the early periods of life, and the internal surface of the sagittal suture. It receives the superior longitudinal sinus in its entire extent; and contains the internal orifices of the parietal foramina.

On *each side* are the frontal fossa, corresponding to the protuberance of the same name, and the internal surface of the fronto-parietal (coronal) suture (*b c*, *fig.* 22.); the encephalic surface of the parietal bone (*b d f c*), and the parietal fossa; the lambdoid suture (*d f*), and the superior occipital fossa. We may remark that the *fossæ* are deeper than would seem to be indicated by the external prominences, because they are partly formed at the expense of the bone itself; and that the *sutures* are less deeply denticulated on their internal than on their external aspect.

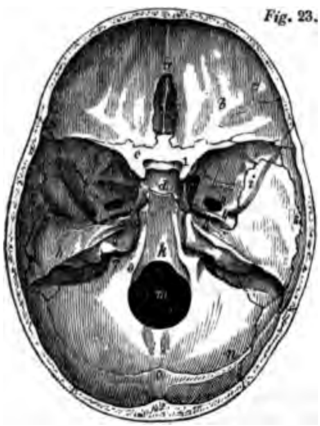
Lastly, the whole internal surface of the vault of the cranium, but especially that of the parietal bones, is traversed by ramified grooves (*b i*), partly for veins, partly for arteries; the venous grooves, which are not perceptible in all subjects, but which are very large in some, are distinguished from the arterial, as M. Breschet has pointed out, by their being perforated by numerous foramina.

The *base of the cranium* (*fig.* 23.), presents three series of fossæ, or three regions, arranged as it were in steps upon an inclined plane, from before backwards, and from above downwards.

* The malar bone is often called the jugal bone, and hence the names of fronto-jugal and spheno-jugal.

Anterior or *ethmoido-frontal region.* In this region we observe, in the middle, the *ethmoidal fossa,* in which is the foramen cæcum; the crista galli (*a*); the ethmoidal grooves, and the foramina with which they are perforated; the ethmoidal fissure, for the ethmoidal or nasal branch of the ophthalmic nerve; the *ethmoido-frontal sutures,* running from before backwards; the orifices of the internal orbitary foramina; and the trace of the *ethmo-sphenoidal suture,* running transversely.

Fig. 23.



Laterally we see the orbital plates (*b*), remarkable for the prominence of their mamillary projections, and traversed by small grooves for the ramifications of the middle meningeal artery; and the *fronto-sphenoidal sutures* (before *c*), which mark the union of the lesser wings of the sphenoid (*c*), with the orbital portion of the frontal bone (*b*). The orbital plates support the anterior lobes of the brain.

The *middle region* exhibits in the centre a fossa, in which we observe the depression for the olfactory nerves, the optic groove, and olivary process (before *d*); the *pituitary fossa* (*d*), deeply excavated behind; the quadrilateral plate (behind *d*); the cavernous grooves; and the anterior and posterior clinoid processes. On *the sides* we find very deep fossæ, which correspond with the middle lobes of the brain, called *middle lateral fossæ* of the base of the cranium; they are broad externally, narrow internally, and are bounded in front by the posterior edge of the lesser wings of the sphenoid (*c*), and behind by the superior border of the petrous portion of the temporal bone (*h*). They are formed by the superior surface of the petrous portion, the internal surface of the squamous portion of the temporal, and the superior surface of the great wings of the sphenoid. They present, successively from before backwards, the sphenoidal fissure (or foramen lacerum superius); the foramen rotundum or superior maxillary (2); the foramen ovale (3); the foramen spinosum (4); the internal orifices of the anterior lacerated foramen, and carotid canal (before 5), and the hiatus Fallopii. We see here also the union of the sphenoid with the squamous and petrous portions of the temporal bone, forming the *spheno-temporal* (*i* and *e*) and *petro-sphenoidal sutures.* This fossa is traversed from behind, forwards and outwards by a groove (*i* 4), which commences at the foramen spinosum, passes along the external border of the sphenoid, or rather is hollowed out from the spheno-temporal suture, and divides into two branches: the anterior, the larger, proceeds to the anterior inferior angle of the parietal bone, with the anterior ramified groove in which it becomes continuous; the posterior is directed horizontally backwards to the posterior inferior angle of the parietal bone. In some cases the portion of the groove which extends from the foramen spinosum to the summit of the lesser wing of the sphenoid, almost equals in diameter the lateral grooves, and it is then almost always pierced by foramina: it contains the middle meningeal artery, and a large vein.

Posterior region of the base of the cranium. This region presents, in the middle, the basilar groove (*k*); *the spheno-occipital suture,* the foramen magnum (*m*), the anterior condyloid foramina (8) (*h, fig.* 22.), the internal occipital ridge, and protuberance (*o, fig.* 21.). Laterally, the *inferior occipital fossæ,* the deepest in the skull, which are formed by the posterior surface of the petrous portion of the temporal bone, almost the whole of the encephalic surface of the occipital bone, and the posterior inferior angle of the parietal. We find here the

posterior lacerated foramen (7), the suture which unites the temporal to the occipital bone, and along the petro-occipital suture, a small groove named *inferior petrosal* (on each side of *k*).

The inferior occipital fossa is bounded above, by a broad and deep groove (*n*), intended to lodge the lateral sinus, and called the *lateral groove*. It commences at the internal occipital protuberance (*o*), and proceeds horizontally outwards to the base of the petrous portion, where it is again enlarged, and passes round, extending downwards and inwards along the occipital fossa, until it arrives at the occipito-mastoid suture (*r*), where it rises and terminates in the posterior lacerated foramen The inferior occipital fossa is divided into two parts by this groove: an anterior, formed by the posterior face of the pars petrosa; and a posterior formed by the occipital bone. In this groove, the *mastoid foramen*, the *posterior condyloid foramen*, when it exists, and the *superior and inferior petrosal grooves* open.

The dimensions of the lateral grooves are extremely variable; most commonly the left is smaller and shallower than the right, especially in its horizontal portion.

Of the eminences and depressions on the internal surface of the cranium, the most deeply marked are those situated upon the base. This is more especially the case, with regard to the orbital plates and the middle and lateral fossæ. Since the publication of the works of Gall and Spurzheim, anatomists have re-adopted the opinion of the ancients, who regarded these eminences and depressions as corresponding respectively with the anfractuosities and the convolutions of the brain: the cranium in fact is moulded upon the brain; to be convinced of which it is only necessary to repeat the following experiment, which I have often made for this purpose. Remove the brain from the cavity of the cranium, and supply its place by plaster of Paris; when dry, this substance will present a faithful model of the convolutions and anfractuosities of the brain. In cases of chronic hydrocephalus, where the inequalities of the brain are effaced by the accumulation of fluid, the internal surface of the cranium shows scarcely any vestiges of eminences and depressions. The osseous tissue, notwithstanding its hardness, is easily moulded around organs, and yields with facility to the compression which soft parts exercise upon it. It is very uncommon to open the cranium of a subject, somewhat advanced in years, without observing in some points a more or less considerable absorption of the parietes of the skull, occasioned either by clusters of certain small white bodies, called glandulæ Pacchioni, or by dilated veins.

One anatomical fact worthy of notice, is the want of any configuration of the external surface conformable in its details with that of the internal surface: compare, for instance, the roof of the orbit with the cranial surface of the orbital plate of the frontal bone. This difference is due to the circumstance that the digital impressions encroach on the diploe, and are in part excavated from the space otherwise occupied by it. The two compact laminæ which form the bones of the cranium, are in some measure independent of each other: the internal one belongs, so to speak, to the brain: the external to the locomotive system. The diploe is the limit of these two laminæ. This anatomical fact is at variance with the doctrine of Gall respecting the protuberances: it proves that the cerebral convolutions are not faithfully represented by external prominences.

In order to complete the anatomical history of the cranium, it yet remains to consider, 1. its general development: 2. the connection of its several parts. (For this latter subject, see SYNDESMOLOGY.)

As to the analogies which have been so ingeniously established between the cranium and the vertebral column, a detailed analysis of them would be out of place in an elementary work like the present.

Development of the Cranium.

The cranium is remarkable for the early period at which its development commences. As soon as the embryo is sufficiently advanced in growth to exhibit any distinction of parts, the head, under the form of an ovoid vesicle, greatly exceeds the magnitude of the whole body. With regard to the order in which the different parts are ossified, we may remark, that the bones of the roof precede those of the base, in like manner as in the vertebræ the laminæ are ossified before the bodies. In both cases the evolution is most prompt in those parts which are especially destined to protect important organs.

Cranial Bones at Birth.

The bones of the roof of the skull appear before those of the base, but at birth ossification is less advanced in the roof than in the base; accordingly, in a fœtus at the full time the bones of the base form a solid whole, and are immovable, while those of the roof are separated by membranous intervals, which permit of pretty extensive movements, so that at this period the roof of the cranium yields in a great degree to pressure. At birth, there is nothing resembling the mode of union called suture. Nevertheless each bone presents denticulations like the teeth of a comb round the circumference. The existence of these indentations before the period when the bones come into contact, proves that they are not the result of any mechanical action produced by their meeting: the only influence of this kind to which they are subjected during their formation, is the deviation of opposing denticulations. The frontal suture is the first developed.

Another peculiarity of this stage of development, is the existence of those membranous intervals denominated *fontanelles.* They are produced in the following manner: the process of ossification commences in the centre of the bone, and advances from that point to the circumference, the most distant parts of the bone being of course the last to be ossified. These points, in broad or flat bones, are the angles, and consequently at the place where several angles of different bones ultimately unite, there must exist an unossified space at this time; these spaces are the fontanelles. They have all been pointed out in the description of the cranial bones: they are of especial importance to the accoucheur, on account of the indications which they furnish for determining the position of the child. All traces of the fontanelles are completely obliterated at the age of four years.

The Wormian Bones.

The Wormian bones should be regarded as supplementary points or centres, developed when the general ossification proceeds somewhat slowly; and we therefore consider it proper, to include a description of them in the account of the development of the cranium.

The Wormian bones, so called because the first description of them has been assigned to Wormius, a physician in Copenhagen, are also denominated *epactal bones, ossa triquetra,* or *complementary* bones of the skull. They are extremely variable both in situation, number, and size; but they are most common in the lambdoid suture, *i. e.* in the most rugged of all the sutures, the asperities of which they tend to increase. This fact should not be overlooked in examining fractures of the cranium. The most remarkable of all the Wormian bones, is the one which sometimes supplies the place of the superior angle of the occipital, and which Blasius has called the *triangular* bone: it is the *epactal* bone properly so called. It is not uncommon to find a Wormian bone in the sagittal suture, and this may be compared to the *inter-parietal* bone of some animals. Bertin has described a quadrangular bone occupying the situation of the anterior fontanelle, and resembling it in figure: I have myself met with such a formation. The anterior inferior angle of the parietal is sometimes formed by a Wormian bone; I have seen one in the squamous suture.

The Wormian bones are not always visible in the interior of the cranium: in some cases they are as it were incrusted in the substance of the bone, at the circumference of which they are observed.

Their mode of development resembles that of the broad bones, *i. e.* it proceeds by radiation from the centre to the circumference. According to Béclard, they are not developed until five or six months after birth: at their junction with the surrounding bones they form sutures, which are the first to become effaced in after life.

From all that has been said regarding this class of bones (which are in a manner *accidental*, for they are neither constant in number nor in their existence), it is evident that they can be only considered as *supplementary points of ossification*, and not as performing an important office in contributing to the solidity of the cranium, as the name *clés de voûte*, given to them by some anatomists, would seem to indicate.

Progress of Development in the Adult and the Aged.

The cartilaginous lamina which separates the bones at first, gradually becomes ossified. The sutures become so serrated, that it is almost impossible to separate the bones, without breaking some of their teeth. At the same time that the bones increase in breadth they augment in thickness; the diploe, which at first did not exist, is developed between the two plates. In the adult several bones already begin to join by osseous union; of this we have an example in the sphenoid and occipital, which at an early period form one bone.

In the aged the traces of the sutures are in a great measure effaced, so that in certain cases the whole skull would seem to be composed of one entire piece. The continuity of some bones is occasionally such, that the venous canals of the one communicate and open directly into those of the other. It is not uncommon to find the bones of an old subject thin and translucent like horn in a greater or less extent. This diminution of thickness, added to the increasing fragility of the osseous tissue, affords an explanation of the ease with which the skulls of old people may be broken: and the continuity of the bones explains the possibility of the fracture being much extended.

THE FACE.

The face is that very complicated osseous structure, which is situated at the anterior and inferior part of the head, and is hollowed out into deep cavities for the reception of the organs of sight, smell, and taste, and for the apparatus of mastication.

The face is divided into two portions, *the upper and the lower jaw.* The lower jaw is formed by one bone only; the upper jaw consists of thirteen bones. But although this circumstance tends to establish a great difference between the two, yet it must be remarked, that all the parts of the upper jaw are so immovably united, that in appearance they form only one bone; and, moreover, that it is essentially formed by one fundamental piece, the superior maxillary bone, to which all the others are attached as accessory parts.

Of the fourteen bones which constitute the face, two only are median or single: viz. the vomer and the inferior maxilla. All the others are double, and form six pairs, viz. the superior maxillary, the malar, palate and proper nasal bones, the ossa unguis, and the inferior turbinated bones.

The superior Maxillary Bones (figs. 24 and 25., with the Palate Bones).

They are two in number, united to a certain extent in the median line, and form almost the whole of the upper jaw. Their figure is very irregular: they belong to the class of short bones. They have three surfaces, an external, an internal, and a superior; and three borders, an anterior, a posterior, and an inferior

External surface (*fig.* 24.). Proceeding from before backwards we observe a small fossa in which the myrtiform muscle (*depressor labii superioris et alæ nasi*), is inserted, and which is bounded externally by the ridge which forms the alveolus of the canine tooth : a deeper fossa, named *fossa canina* or *infra orbitalis*, surmounted by the orifice of the *infra orbitary canal* (*o*) :—and more posteriorly a vertical ridge, which separates the fossa canina from the *maxillary tuberosity* (*m*). This protuberance, which is most prominent before the appearance of the wisdom tooth, is traversed by small canals, the *posterior and superior dental*, which transmit vessels and nerves of the same name. From the anterior part of this region a long vertical process arises, the *ascending* or *nasal process* (*a b*) of the superior maxilla. It is of a pyramidal shape and flattened. Its *external surface* is smooth, and presents the openings of certain vascular canals which communicate with the interior of the nasal fossæ, and some inequalities for the insertion of the common elevator of the upper lip and ala of the nose. On the *internal surface* (*fig.* 25.) we observe in succession from above downwards a rough surface, which assists in closing the anterior cells of the ethmoid; a horizontal ridge to which the middle turbinated bone is attached; a concave surface, which forms part of the middle meatus of the nose; and another horizontal ridge for articulation with the inferior turbinated bone : like the external, this surface also is perforated by foramina, and marked by arterial furrows. Its *anterior edge* (*a b*, *figs.* 24, 25.) thin, and bevelled internally, is applied to the nasal bone. The *posterior edge* is thick and marked by the *lachrymo-nasal groove*, which forms part of the *lachrymal groove* above, and of the *nasal duct* below. It has two edges or lips : the internal, which is very thin, articulates with the os unguis and the inferior turbinated bone; the external, which is rounded, gives attachment to the straight tendon and some fibres of the orbicularis palpebrarum muscle. The direction of the lachrymo-nasal groove is slightly curved; the convexity being internal and in front, the concavity external and behind. The summit of the nasal process is truncated and serrated for articulation with the nasal notch of the frontal bone.

Superior or *orbital surface* (*e*, *fig.* 24.). This is the smallest of the three surfaces. It forms almost the entire floor of the orbit; it is triangular, and slightly oblique from within outwards, and from above downwards, and presents a groove behind, which is continuous with the infra-orbitary canal. This last-named passage, at first a mere channel, afterwards a complete canal, passes from behind forwards and inwards, bends down and opens at the upper part of the canine fossa. Before its termination, it gives off a small canal, *the anterior and superior dental*, which runs in the anterior wall of the maxillary sinus, and transmits the vessels and nerves which are distributed to the incisor and canine teeth. Sometimes this branch of the canal opens into the maxillary sinus. In many subjects I have seen it curve backwards, and conduct a communicating branch between the infra-orbitary and palatine nerves as far as the maxillary tuberosity. The orbital surface is bounded by an *external edge*, which forms part of the spheno-maxillary fissure; by an *internal edge*, which articulates with the os unguis, the os planum of the ethmoid, and the palate bone : and by an *anterior edge*, which forms part of the rim of the orbit. At the external termination of this edge is a very irregular eminence, appearing as if part of the bone had been broken off : this is the malar process, which corresponds with the summit of the maxillary sinus, and is articulated with the malar bone. At the internal extremity of the orbital edge, we find the ascending process already described.

Internal or *naso-palatine surface* (*fig.* 25.). This surface is divided into

two unequal parts by a horizontal square plate, which intersects it at right angles. This plate is the *palatine process* (*t*), the superior surface of which, smooth and hollowed, is broader posteriorly than anteriorly, and forms part of the floor of the nasal fossæ: its inferior surface is rough, and forms part of the roof of the palate: its internal border (*t*) is very thick in front, and articulates with the corresponding edge of the opposite bone. This border is surmounted by a crest, which contributes to form the furrow into which the vomer is received, and which presents, at the junction of its anterior with the two posterior thirds, a groove (*r*) running obliquely upwards and backwards. This groove, when united with a similar one on the opposite bone, forms the *anterior palatine* or *incisive canal*, which is single below and double above. The anterior edge of the palatine process is very narrow, and forms part of the anterior opening of the nasal fossæ: the posterior edge, bevilled at the expense of the superior table, supports the horizontal portion of the palate bone.

That part (*w*) of the internal surface of the maxillary bone which is situated below the palatine process, is of no great extent: it forms part of the arch of the palate. A furrow, more or less deep, and bounded by projecting edges, runs along the external border of the palatine process, and protects the posterior palatine vessels and nerves. The mucous membrane of the palate covers this region of the bone The part of the internal surface (*n*) of the superior maxillary bone which is above the palatine process, belongs to the nasal fossa: it is covered by the pituitary membrane. We observe here from before backwards, 1. the internal surface (*c*) of the ascending process (*a*): 2. below the inferior ridge, a smooth surface which forms part of the inferior meatus of the nose: 3. the inferior orifice (behind *c*) of the lachrymo-nasal groove, sometimes converted into a complete canal by a bridge of bone: 4. the opening of the maxillary sinus (*s*), which appears wide in a detached bone, but in its natural connection is contracted by prolongations of the palate bone, the ethmoid, the inferior turbinated bone, and the os unguis, all of which are articulated with the circumference of this opening; it is still further diminished when the bones are covered by their pituitary membrane. At its lower part, this orifice presents a fissure in which a lamina belonging to the palate bone is received: this method of articulation has received the name of *Schindilesis*. At the upper part are small cells, which unite with the ethmoid: behind the orifice is a rough surface, which articulates with the palate bone: and, lastly, a groove, which forms part of the posterior palatine canal.

The orifice which we have just described leads into the interior of a cavity, denominated *maxillary sinus*, or *antrum of Highmore*, although it had been before very accurately described by Vesalius. It is hollowed out from the substance of the maxillary bone, and has the form of a pyramid, the base of which corresponds with the internal surface of the bone; the summit with the malar process; the superior wall with the floor of the orbit; the anterior wall with the fossa canina, and the posterior with the maxillary tuberosity. These two last mentioned walls are traversed by linear projections or ridges, which correspond with the anterior and posterior dental canals. There is also one ridge upon the superior wall: it indicates the passage of the infra-orbitary canal. The extreme tenuity of this superior or orbitary wall is an anatomical fact of great importance, because it explains the influence which tumours developed in the sinus exert upon the organs contained in the cavity of the orbit. The septum between the sinus and the bottom of the alveoli is also so thin, that an instrument can easily penetrate into the sinus in this situation. This remark applies particularly to the alveolus of the canine tooth.

The *anterior border* (*g a*, *figs.* 24 and 25.) of the superior maxilla presents below a vertical portion (*g d*), surmounted by a small eminence called the *nasal spine* (*a*): it is then hollowed out into a deep notch (*a b*), to form half the anterior orifice of the nasal fossæ; and, lastly, becomes continuous with the anterior edge (*b a*) of the ascending process.

The *posterior border* is vertical and very thick: it articulates below with the

pterygoid process, through the medium of the palate-bone: above it forms part of the pterygo-maxillary fissure.

The *inferior* or *alveolar border* (*g h*) is the thickest and strongest part, being, in some respects, the base of the bone. It is hollowed into conical cavities separated by thin septa. These cavities are the alveoli or sockets of the teeth: they are proportioned in dimensions to the size of the fangs which they are intended to lodge, and in like manner are subdivided into two, three, or four secondary cavities. The bottom of these alveoli is in apposition with the maxillary sinus, into which they occasionally open. This border presents, especially in front, flutings or projections which correspond with the alveoli, and depressions which mark the inter-alveolar septa.

In young subjects we may observe, chiefly behind the incisor teeth, some very remarkable foramina, to which much importance has been attached as connected with the phenomena of dentition.

Internal structure. This bone is remarkably light for its size, on account of the large cavity which it incloses. It is more compact than most of the short bones, and has spongy tissue only in the alveolar border, the maxillary tuberosity, and the malar eminence.

Connections. The superior maxilla is articulated with two bones of the cranium, the frontal and the ethmoid, and with all the bones of the face. It lodges eight of the teeth of the upper jaw.

Development. Anatomists are not at all agreed respecting the number and arrangement of the osseous points, which concur in forming the superior maxilla.

In the maxillary bone of the fœtus, and sometimes even in that of the adult, there are, as I can attest from observation, two very remarkable fissures, which would seem to indicate the primitive separation of the bone into three pieces.

1. The first fissure which may be called the *incisive fissure*, is visible on each side of the arch of the palate. It commences at the septum, which divides the alveoli of the canine tooth and lateral incisor; is continued backwards to the anterior palatine canal; and is prolonged above on the internal surface of the ascending process. This fissure is apparent only on the internal surface of the superior maxilla: it either does not exist at all upon the external surface, or is so early obliterated, that it can scarcely ever be met with. The portion of the maxilla circumscribed by this fissure sustains the incisor teeth, and represents the incisor or inter-maxillary bone of the lower animals. In hare-lip the solution of continuity is in the situation of this fissure. It is therefore probable that this anterior portion of the maxillary bone is developed from a special point. Bertin asserts this, and Meckel and Béclard admit it. I have not been able to observe such independent development, at any period of fœtal life at which I have examined the maxillary bone.

2. A second and equally constant fissure is visible in the situation of the infra-orbital canal, and is prolonged from the edge of the orbit in the form of a small suture to the anterior orifice of this canal: it may be called *the orbital fissure.* This fissure, like the preceding, has always seemed to me incomplete, and not occasioned by the separation of a distinct piece.

The superior maxillary bone is one of the earliest in making its appearance. Ossification commences in it from the thirtieth to the thirty-fifth day, in the situation of the alveolar arch.

At birth the superior maxilla has little height, but a considerable extent from before backwards. At this period it is chiefly formed by the alveolar border, which is almost contiguous to the floor of the orbit. The maxillary sinus is already very apparent. In the adult, the vertical dimensions increase by enlargement of the sinus. In the aged, the alveolar process becomes flattened, and diminished in height.

The Palate Bones (*figs.* 24, 25, 26, and 27.).

The palate bones are situated at the posterior part of the nasal fossæ and the palatine arch; they are two in number, symmetrical, and each composed of two thin quadrilateral laminæ, one of which is horizontal, the other vertical, and which are joined together at right angles.

Fig. 26. Fig. 27.

The *horizontal plate* (*b c*, *figs.* 26 and 27.), the only one known to the ancients, and named by them the *os quadratum*, presents a *superior surface* (*d f*), smooth, and continuous with the floor of the nasal fossæ, of which it forms the broadest part: an *inferior surface* (*b c*), which completes the arch of the palate: it is rough, slightly concave in front, and presents behind and to the outside a transverse ridge for the insertion of the tensor palati muscle; and in front of this ridge is the inferior orifice of the posterior palatine canal. The *anterior edge* of this plate is cut obliquely, so as to rest upon the posterior edge of the palatine process of the superior maxillary. The *posterior edge* is concave, and very thin; it gives attachment to the velum palati. The *internal edge* is surmounted by a crest, which forms one of the sides of the furrow for the vomer, and terminates behind by a sharp process (*d*), which, when united to the corresponding part of the opposite bone, constitutes the *posterior nasal spine*, which gives attachment to the levator muscle of the uvula (azygos uvulæ). The *external edge* is united to the vertical portion of the bone.

The *vertical portion* or *lamina* (*a b*) is slightly inclined inwards, quadrilateral, longer, broader, and thinner than the preceding. On it we observe, 1. An *internal surface* (*m f* and 2, *fig.* 25.), which contributes to form the external wall of the nasal fossæ, and which presents from above downwards a horizontal ridge for articulation with the middle turbinated bone: a groove belonging to the middle meatus: another ridge for articulation with the inferior turbinated bone (*e*, and 2, *fig.* 25.): and another groove which makes part of the inferior meatus (*e f* and 1, *fig.* 25.). 2. An *external surface* (*s b*, *fig.* 26.; and *p b*, *fig.* 27.) very irregular, which contributes to form the bottom of the zygomatic fossa above, and which is rough in front for union with the superior maxillary. This surface is traversed by a vertical groove, which by itself forms almost the entire extent of the *posterior palatine canal* (*g g*, *fig.* 26.). 3. An *anterior* or *maxillary border* (*i*, *fig.* 27.), very thin and irregular, which advances so far forwards as to contract the entrance into the maxillary sinus, and presents a tongue of bone which is received into the fissure already described as existing at this orifice. 4. A *posterior* or *pterygoid border* (*l*, *fig.* 26.), which is applied to the inner plate of the pterygoid process. There is below, at the angle formed by its union with the posterior edge of the horizontal portion, a very considerable process, for the size of the bone: this has been called *palatine process*, or *tuberosity of the os palati* (3, *fig.* 25.; *l b*, *fig.* 26.), but is better named *pterygoid* or *pyramidal process:* its base is continuous with the rest of the bone, and from this point it passes downwards, and is as it were inclosed in the bifurcation of the pterygoid process of the sphenoid. Its upper surface is traversed by three grooves, the middle of which forms part of the pterygoid fossa, and the lateral ones are rough and receive the summits of the two pterygoid plates. Below, the pyramidal process exhibits the orifices of the *accessory ducts of the posterior palatine canal.* Externally it presents a rough surface, which articulates above with the tuberosity of the superior maxilla, and which is free in the rest of its extent, and forms part of the zygomatic fossa. The middle of this process is grooved in a vertical direction, for the posterior palatine canal. 5. The *inferior border* of the vertical portion

is continuous with the external edge of the horizontal plate. 6. The *superior* or *sphenoidal border* is connected with the sphenoid in almost the whole of its extent. It presents a deep notch forming three fourths or sometimes the entire *spheno-palatine foramen* (6, *fig.* 25.; *o*, *figs.* 26, 27.; *n*, *fig.* 37.), which corresponds with the *spheno-palatine ganglion*, and gives passage to the vessels and nerves of the same name. This border is surmounted by two *processes*, an *anterior* or *orbital* (4, *fig.* 25.; *a*, *figs.* 26, 27.), and a *posterior* or *sphenoidal* (5, *fig.* 25.; *m*, *figs.* 26, 27.). The *sphenoidal process* is the broader, particularly at its base, but is not so elevated as the anterior: it presents three facettes, an internal, which forms part of the nasal fossa; an external, which is visible in the zygomatic fossa; and a superior, which articulates with the sphenoid, and presents a groove which contributes to form the *pterygo-palatine canal.*

The *orbital process*, inclined outwards, and supported by a constricted portion or neck, has five facettes. *Three of these are articular*, viz. *the internal* (*n*, *fig.* 27.), which is concave, and unites with the ethmoid, covering and completing its cells; *the anterior* (*p*, *fig.* 27.), which joins the maxillary bone; and *the posterior* (*q*, *fig.* 26.), which is united to the sphenoid by certain asperities surrounding a cell, which exists in the substance of the process and communicates with the sphenoidal sinus. *The other two are non-articular*, viz. the *superior* (*r*, *fig.* 26.), which forms the deepest part of the floor of the orbit, and *the external* (*s*, *fig.* 26.), which forms part of the zygomatic fossa, and is separated from the preceding by a small edge, which constitutes a portion of the spheno-maxillary fissure.

Internal structure. The palate bone is compact throughout, excepting in the palatine process, where it is thick and cellular.

Connections. The palate bone articulates with its fellow on the opposite side, with the maxillary, the sphenoid, the ethmoid, the inferior turbinated bone, and the vomer.

Development. This bone is developed from a single point of ossification, which appears from the fortieth to the fiftieth day, at the point of union of the vertical and horizontal portions, and the pyramidal process. During its development the bone appears as it were crushed down, so that the vertical portion is shorter than the horizontal, and there is a marked predominance in the antero-posterior diameter. This disposition is in accordance with the shortness of the vertical diameter of the superior maxilla.

The Malar Bones (*fig.* 28.).

The *malar bones*, called also *cheek*, *jugal*, or *zygomatic bones*, are situated in the superior and lateral part of the face: their form is that of a very irregular four-sided figure. They have three surfaces, an anterior, a posterior, and a superior; four borders, and four angles.

Fig. 28.

The *anterior* or *cutaneous surface* (*a*) looks outwards, is convex and smooth, and presents the openings of several foramina (*h*), named malar, which are intended for nerves and vessels. This surface gives attachment below to the *zygomaticus major* muscle. It forms the most prominent part of the cheek, and is covered only by the skin and *orbicularis palpebrarum* muscle: it is consequently much exposed to injury.

The *superior* or *orbital surface* (*b*) is supported by a thick curved process, the *orbital process*, which arises from the bone almost at a right angle. This surface is concave, and of small extent: it forms part of the orbit, exhibits the internal openings of one or more malar foramina, and terminates behind by a rough, serrated edge, which articulates above with the frontal and sphenoid bone, and below with the superior maxillary. The same maxillary edge presents in the middle a retiring, smooth angle, which constitutes the anterior extremity of the *spheno-maxillary fissure.*

The *posterior* or *temporal surface* is concave, and presents a smooth surface behind, which contributes to form the temporal fossa, and on which one or more malar foramina open; and a rough surface in front, which unites with the malar process of the superior maxilla.

Of the *four borders* two are superior; of these the anterior or *orbital* (*d e*), is semi-lunar, rounded, and blunt, and forms the external third of the base of the orbit: the posterior or *temporal* (*e f*), is thin and curved like the letter S. and bounds the temporal fossa in front. Of the two inferior borders, the anterior or *maxillary* (*d g*), is very rough,and articulates with the maxillary bone: the posterior or *masseteric* (*g f*) is horizontal, thick, and tubercular, and gives attachment to the masseter muscle.

Of the *four angles*, the *superior* or *frontal* (*e*), which is much elongated, and vertical, is the thickest part of the bone, and articulates with the external orbital process of the frontal bone: the *posterior* or *zygomatic* (*f*), broader and thinner than the preceding is serrated, and slants downwards and backwards for articulation with the zygomatic process of the temporal bone, which rests upon it. The *internal* or *orbital* angle (*d*), looks inwards and forwards, is very acute and articulates with the superior maxillary, near the infra-orbitary canal. The *inferior* or *malar* angle (*g*) looks downwards, is obtuse, and unites with the outer part of the malar or jugal process of the superior maxillary.

Internal structure. The malar bone is almost entirely compact, possessing spongy tissue only in the anterior and inferior edge, and in the part where the orbital portion is given off. It is constantly traversed by a canal, called *zygomatic.* This passage is generally simple, but sometimes double or even multiple, and opens by at least three orifices. The superior or orbital orifice is visible on the surface of the same name; the next or external zygomatic foramen is on the cutaneous surface of the bone; and the third or internal zygomatic on the inner surface of the vertical portion.

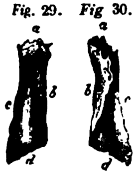
Connections. The malar bone is articulated with the superior maxillary, the frontal, the sphenoid, and the temporal.

Development. It is developed from one point of ossification which appears about the fiftieth day of fœtal life. The ulterior changes which it undergoes do not require particular notice.

The Nasal Bones (*figs.* 29, 30.).

The nasal bones are two in number, asymmetrical, and very small in the human subject; they are closely contiguous to each other, sometimes united into one piece superiorly. They are situated at the upper and middle part of the face, and form, as their name indicates, the osseous part of the nose, of which they constitute the root. They are directed obliquely downwards and forwards, but with various degrees of inclination in different subjects; and hence the varieties in the shape and prominence of the middle or bridge of the nose. Their figure is rectangular and oblong; they are thick and narrow above, broad and thin below; and have two surfaces, an anterior and a posterior, and four edges.

Fig. 29. Fig 30.



The *anterior* or *cutaneous surface* (*fig.* 29.) is covered only by the skin and pyramidalis nasi muscle, and hence the ease with which these bones are fractured; it is concave above, flat or even convex below: the orifice of a vascular canal is always very distinctly seen, which is variable in its situation sometimes single, but often accompanied by others of smaller size.

The *posterior* or *pituitary surface* (*fig.* 30.) is concave, and forms the anterior part of the roof of the nostrils: it is marked by vascular and nervous furrows, and in the fresh state is covered by the pituitary membrane.

Of the four edges, the *superior* (*a*, *figs.* 29, 30.), short, thick, and serrated, articulates with the nasal notch of the frontal bone. The *inferior* (*d*) very thin, and more elongated, has a slight notch *in the* centre for the passage of a

nervous filament, and forms part of the anterior orifice of the nasal fossæ; it unites with the lateral cartilage of the nose. The *internal* (*b*) edge is thick above and bevilled, so that, when approximated to the other bone, the two constitute a furrow, in which the nasal spine of the frontal and the perpendicular lamella of the ethmoid bone are received. The *external* (*c*) edge is somewhat longer than the internal, is slightly bevilled on the outer table, and indented for articulation with the ascending process of the superior maxilla, which rests upon it.

Connections. The two bones are articulated together; they unite also with the frontal, the ethmoid, and the superior maxilla, and likewise with the lateral cartilages of the nose; they afford passage to the vessels which establish a communication between the skin of the nose, and the mucous membrane of the nasal fossæ.

Internal structure. The nasal bones are thick and cellular in their upper parts, thin and entirely compact in their lower, and are traversed by nervous and vascular grooves.

Development. The nasal bone is developed from one single osseous point, which appears before the end of the second month.

Ossa Unguis, or *Lachrymal Bones* (*figs.* 31, 32.).

These are the smallest bones of the face; they are thin like paper, and have the transparence, tenuity, and even the shape of a nail, from which circumstance one of their names has been derived. They are situated at the internal and anterior part of the orbit; their figure is irregularly quadrilateral; they are two in number, and therefore asymmetrical. They have two surfaces and four edges.

Fig. 31.

Fig. 32.

The *external* or *orbital surface* (*fig.* 32.) is divided into two unequal parts by a vertical ridge (*a b*), which terminates below in a sort of hook. The portion anterior to the ridge is narrow, and marked by a porous groove (*c*), which when joined to the channel on the ascending process of the superior maxilla forms the *lachrymal groove* (hence the name of lachrymal bone).* The portion (*d*) of the os unguis, which is posterior to the ridge, completes the inner wall of the orbit.

The *internal* or *ethmoidal surface* (*fig.* 31.) presents a furrow (*a′ b*) which corresponds to the external ridge; the portion (*c′*) in front of the furrow forms part of the middle meatus; behind is a rough surface (*d′*) which covers the anterior cells of the ethmoid.

Of the four borders, the *superior* (*a a′*) is rough, and articulates with the internal orbital process of the frontal bone; the *inferior* (*b b′*) articulates with the inferior turbinated bone, by a small tongue which passes backwards, and which contributes to form the nasal canal, and with the internal edge of the orbital surface of the superior maxillary. The *anterior edge* (*e e′*) unites with the ascending process of the maxillary bone; and the *posterior edge* (*f f*), slightly denticulated, joins the orbital portion or lamina papyracea of the ethmoid.

Connections. The os unguis articulates with the frontal, the ethmoid, the superior maxillary, and the inferior turbinated bone.

Structure. The os unguis consists of a very thin layer of compact tissue, and is the most brittle of all the bones. It is of importance to note its tenuity and fragility, because it is concerned in the operation for fistula lachrymalis.

Development. The os unguis is ossified at the commencement of the third month, from one single point.

* The existence of lachrymal bones is subordinate to that of the lachrymal secretion. They are not met with in those animals which live in the water, and which have neither lachrymal glands nor passages.

The inferior Turbinated or *inferior Spongy Bones* (*figs.* 33, 34. and *d*, *fig.* 37.).

The inferior turbinated bones, so called on account of their curved figure, are situated at the lower part of the external wall of the nasal fossæ (*d*, *fig.* 35.), below the ethmoid, whence the name *sub-ethmoidal turbinated* bones. They are two in number, asymmetrical, and their greatest diameter is directed from before backwards. They have two surfaces, two edges, and two extremities.


Fig. 33.


Fig. 34.

The *internal surface* (*fig.* 34. and *d*, *fig.* 37.) is convex, and looks towards the septum of the nose, which it sometimes touches when that part deviates from the straight *direction*; the *external surface* (*fig.* 33.) is concave, and forms part of the middle meatus. Both are rough and as it were spongy, which has given rise to the assertion that these bones form an exception to the general rule of the spongy tissue being in the interior of bones: this appearance, however, is owing to the multiplicity of canals intended for nerves, and more particularly for veins which expand over the bone. The *superior* or *articular edge* (*a b c d*, *figs.* 33, 34.) is very irregular, and presents from before backwards — 1. a thin edge (*a b*) which articulates with the ascending process of the superior maxilla: 2. a small eminence bearing the name of *nasal* or *lachrymal process* (*b*), which articulates by its apex with the os unguis, and by its two edges with the two lips of the ascending process of the superior maxillary to complete the nasal canal: 3. a curved plate, called *auricular process* (*e*, *fig.* 33.) by Bertin, who compared it to the ear of a dog; this plate is directed downwards, and applied partially upon the orifice of the maxillary sinus, which it assists in closing: 4. behind this process we find a thin edge (*e d*, *figs.* 33, 34.), which articulates with a small ridge on the palate bone: 5. between the auricular and the lachrymal processes, are small prominences which unite with the ethmoid.

The *inferior* or *free* border (*a d*) is convex, and thicker in the middle than at its extremities; it is separated from the floor of the nostrils by an interval (*m o*, *fig.* 37.) of uncertain extent, a circumstance to be remembered during the introduction of instruments into the nasal fossæ.

The *anterior extremity* (*a*) is a little less pointed than the *posterior* (*d*), which distinguishes the bone of the right from that of the left side.

Connections. The inferior turbinated bones articulate with the superior maxillary, the palate bones, the ethmoid, and the ossa unguis: they have important relations with the inferior orifice of the nasal canal, which they defend from the contact of foreign bodies.

Structure. Their external spongy appearance depends upon the multitude of canals with which their surface is furrowed, but they are almost exclusively formed of compact tissue.

Development. Their ossification commences about the fifth month of fœtal life, by a point situated in the centre.

The Vomer (*fig.* 35. and 10, *fig.* 22.).

The *vomer* is so called from its supposed resemblance to a ploughshare. It is situated in the median plane, and forms the posterior part of the septum of the nostrils. It is thin, flat, and quadrilateral, and has two surfaces and four edges. The *surfaces* are placed laterally (as at *a*, *fig.* 35.), and are generally plane, but they are often bent to one side or the other, and are then convex and concave in opposite directions —; they are always smooth and covered by


Fig. 35.

the pituitary membrane, and present small vascular and nervous furrows. The *superior* or *sphenoidal* border (*b*, *fig.* 35. and 3, *fig.* 22.) is the shortest and thickest: it is marked by a deep groove which receives the inferior crest of the sphenoid; the two lips of the groove are bent outwards, and received into furrows on the inferior surface of the same bone, and thus complete a small channel for the passage of vessels and nervous filaments. The *inferior* or *maxillary* (*c*) border is the longest, and is received into the furrow which is formed by the union of the two palate bones, behind, and of the two superior maxillary in front: it sometimes terminates by a more or less prominent process behind the anterior nasal spine. The *anterior* or *ethmoidal* border (*d*, *fig.* 35. and 3 4, *fig.* 22.) presents the continuation of the groove on the superior edge, and receives the inferior border of the perpendicular plate of the ethmoid. There is no groove, where it is attached to the cartilaginous septum. The *posterior* or *guttural edge* (*e*, *fig.* 35. and *t*, 10, *fig.* 22.) is free: it is thin and sharp, and inclines downwards and forwards: it separates the posterior openings of the nasal fossæ.

Connections. The vomer is articulated with the sphenoid, the ethmoid, the superior maxillary, the palate bones, and the cartilage of the septum.

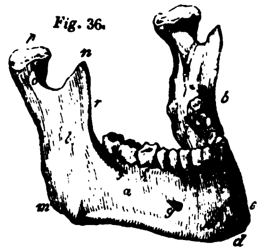
Internal structure. The vomer is composed of two very thin compact laminæ which are distinct above but united below. Some anatomists have called these plates, *alæ of the vomer.*

Development. It is developed from one point of ossification, which is situated at the lower part of the bone, and appears before the end of the second month. It then presents the form of a deep groove, embracing the cartilage just as at a future period it embraces the sphenoidal crest. At birth the vomer is still only a groove; afterwards this condition is confined to the sphenoidal and ethmoidal edges of the bone. It is not uninteresting to note the peculiar and uncommon manner in which the ossification proceeds from the surface to the interior of the cartilage.

Inferior Maxilla (*fig.* 36.).

While, as we have before observed, a considerable number of bones enter into the formation of the upper jaw, the lower jaw consists of one bone only. The inferior maxilla occupies the lower part of the face. It has the shape of a parabolic curve, the two extremities of which, called *rami*, form a right angle with the middle portion or *body*.

Fig. 36.



Of the *body* or *middle portion* (*a*). The body represents a curved plate, convex in front and concave behind. It offers to our notice an anterior and a posterior surface, and a superior and inferior border. The *anterior surface* has in the middle a vertical line, called *symphysis menti* (*c d*): it marks the place of union of the two pieces of which this bone is composed in young subjects, and which in a great number of animals remain distinct through life.*

The mode in which the two halves of the body of the inferior maxilla are united, forming an arch, instead of an angle as in other animals, constitutes one of the distinctive characters of the human species; and the *vertical direction* of the symphysis, compared with its very oblique inclination downwards and backwards, or almost horizontal position in the lower animals, is a no less characteristic mark of man, who alone can be said to possess a *chin.*

In front the symphysis terminates by a triangular eminence called *mental process* (*d*). Behind, it presents below four small tubercles, two superior and

* In serpents these pieces form a movable joint; and as a similar arrangement obtains between the two halves of the upper jaw, these reptiles are enabled to swallow an object much larger than their head, or even than their body.

two inferior, known by the collective appellation of *genial processes* (γένειον the chin), and give attachment to the genio-hyoid and genio-glossal muscles.

On each side of the *symphysis*, we observe on the *anterior* or cutaneous surface of the body of the inferior maxilla, 1. a small depression, for the attachment of muscles, named *mental fossa* (*e e*) : 2. a line, which commences at the mental process, passes obliquely upwards, and becomes continuous with the anterior edge of the ramus of the jaw ; it is named the *external oblique*, or *external maxillary line* (*e f*), and is also intended for muscular insertions : 3, above this line, the *mental foramen* (*g*), the orifice of the *inferior dental canal*, which transmits the mental vessels and nerves : 4. the anterior surface of the *alveolar arch* (*c h*), marked by a series of projections corresponding to the alveoli, and separated by vertical depressions which point out the situation of the inter-alveolar septa : 5. below the external oblique line, a smooth surface (*a*) separated from the skin by the platysma myoides muscle.

The *posterior* or *lingual surface* is in some measure moulded upon the tongue : it presents, 1. the *mylo-hyoidean line* (*k*) (μύλος, *dens molaris*), called also *internal oblique* or *internal maxillary*, which commences at the genial processes, and passes upwards and backwards, becoming more prominent opposite the last molar tooth : 2. below this line, a broad but superficial depression, which lodges the sub-maxillary gland : 3. above the oblique line, and near the symphysis, a *fossa* which lodges the sub-lingual gland, and a smooth surface covered by the mucous membrane of the mouth and gums.

These two lines, the external and internal oblique, divide the body of the inferior maxilla into two parts, a *superior* or *alveolar*, and an *inferior* or *basilar*. The first named constitutes almost the entire body of the bone in the fœtus and the infant ; in the adult it forms only two thirds of the depth of the bone, the other third being the basilar portion : lastly, in the aged, the alveolar portion almost entirely disappears, and the basilar only is left.

The *superior* or *alveolar border* describes a smaller curve than the corresponding alveolar edge of the superior maxilla ; so that, in a regular conformation of the parts, the inferior incisor teeth are overlapped by the superior. This border is less thick in front than behind, where it projects inwards ; it is pierced by a series of sockets or alveoli, resembling those of the superior maxilla, and like them variable according to the kind of teeth which they are intended to receive.

The *inferior border* or *base of the jaw* (*d m*) is the thickest part of the bone ; it forms part of a larger curve than the superior border, so that the jaw projects forwards in some measure at the lower part : this projection varies much in different subjects.

Rami of the inferior muxilla (*b b*). These are quadrilateral, and present, 1. *an external surface* (*b*) covered by the masseter muscle, which is inserted into it, especially below, where we may observe depressions and ridges, and where the bone itself is more or less bent outwards ; in front of these ridges is a slight mark which corresponds with the situation of the facial artery : 2. an *internal* or *pterygoid surface*, also rough, for the attachment of the internal pterygoid muscle, and on which is observed the superior orifice (*l*) of the inferior dental canal, which is wide, and has a sort of spine, to which the internal lateral ligament of the temporo-maxillary articulation is attached ; a small groove passes from this orifice in the same direction as the canal, and bears the name of *mylo-hyoidean furrow*, because it lodges the nerve of that name : 3. a *posterior* or *parotid* edge, which is round, and gives attachment below to the stylo-maxillary ligament : it is embraced by the parotid gland : 4. an *anterior edge* (*r*), marked by a groove, which is the continuation of the alveolar border ; the anterior and posterior lips of this groove being formed by the external and internal oblique lines : 5. a *superior edge* very thin, and hollowed out into a deep notch, called *sigmoid notch* (*n o*), on account of its shape, giving passage to nerves and vessels : 6. an *inferior edge*, which is nothing more than a continuation of the inferior border of the body of the bone.

The angle which the rami form with the body of the bone, is named the *angle of the jaw* (*m*). It is a right angle in the adult, but very obtuse in the infant, as also in the carnivora and some of the rodentia, this disposition enabling its muscles to act with greater power.

The rami of the inferior maxilla are terminated above by two processes; the anterior, called the *coronoid process* (*n*); the posterior named the *condyle* (*p*).

The *coronoid process* is triangular, and inclined forwards; broad at its base, and pointed at its summit; it gives attachment to the temporal muscle. The size of this process in the different species of animals bears an exact and constant proportion, both to the depth and extent of the temporal fossa, and to the strength and curvature of the zygomatic arch.

The *condyle* articulates with the glenoid cavity of the temporal bone; it is an oblong eminence, the greatest diameter of which is directed slightly inwards and backwards. It is supported by a contracted portion, called the *neck of the condyle* (*cervix*) (*o*). This neck is turned inwards, in such a manner, that the condyle which it supports, does not project beyond the external plane of the ramus of the jaw; it is also pretty deeply excavated internally to afford attachment to the external pterygoid muscle. The neck of the condyle is the weakest part of the inferior maxilla.

Connections. The inferior maxilla articulates with the temporal bone, and lodges the lower range of teeth.

Structure. The external surface of the inferior maxilla is composed of compact tissue; the interior of the bone assumes the form of diploe, and is traversed for a great part of its extent by the *dental* or *inferior maxillary canal*, which transmits the vessels and nerves that are distributed upon the teeth of this jaw. This canal commences at the middle of the ramus, by a groove covered with a fibrous lamina, the only use of which, as it appears to me, is to protect the vessels and nerves, and to separate them from the internal pterygoid muscle. From this point it proceeds forwards and inwards below the mylo-hyoidean line, the curvature of which it follows; it gradually becomes contracted in diameter; and in the situation of the second small molar or bicuspid tooth, it divides into two canals, the larger of which is very short, and opens upon the external surface of the body of the bone at the *mental foramen* already described; the other, very minute, pursues the original tract, and is lost near the middle incisor tooth. In its passage the inferior dental canal communicates with the alveoli, by one, and sometimes two foramina, through which the vessels and nerves of the teeth are transmitted. The situation of the dental canal varies much in different periods of life. In the new-born infant, before the appearance of the teeth, it occupies the lowest portion of the jaw; after the second dentition, it corresponds pretty nearly with the mylo-hyoidean line: and after loss of the teeth, it runs along the alveolar border. In the inferior maxilla of the old subject, the anterior orifice of the dental canal, or the mental foramen, is close to the superior border of the bone. The dimensions of the dental canal are no less remarkable for their variations; it is very large in the fœtus, and in the child before the appearance of the second set of teeth; it diminishes during adult age, and is much contracted in the old subject.

Development. The inferior maxilla is developed by two points of ossification, one for each lateral half. Antenrieth admits in addition three complementary points; one for the condyle, one for the coronoid process, and one for the angle; but I have never observed them. The case is different, however, with a point of ossification described and figured by Spix, which forms the inner side of the alveolar börder, or rather of the dental canal. In a fœtus of about fifty or sixty days, I have seen a kind of bony spiculum, which passed along the internal surface of the body and ramus of the bone; on the one half of the maxillary bone this spiculum was entirely free; but that of the other side adhered by the interal third of its length. The spine, which surmounts the dental canal, is nothing more than the extremity of this bony spiculum.

It follows, therefore, that the inferior maxilla is developed from four points of ossification.

The inferior maxilla takes precedence of all the bones of the head in its development, and indeed of all the bones of the skeleton, excepting the clavicle. The inferior edge of the body of the bone appears as early as the thirtieth or thirty-fifth day; this extends backwards to form the ramus, and in front to form the portion which supports the incisor teeth; it is probable that the osseous point of the dental canal, mentioned above, appears at the same time. From the fiftieth to the sixtieth day, each half of the bone appears already marked by a groove common to the dental canal and the alveoli. At a later period, the groove becomes very considerable, and is divided into alveoli by septa, which at first are incomplete but afterwards become perfect; the alveoli and their septa occupy at this time the entire depth of the bone.

The point of ossification described by Spix, is united to the rest of the bone from the fiftieth to the sixtieth day. (Spix affirms that it remains separate until the fourth month). The two halves of the maxilla are joined together during the first year after birth. The traces of this union exist for some time, but are afterwards effaced; in the lower animals the suture remains throughout life.

The changes which the inferior maxilla undergoes after birth, relate, 1. to the angle which the ramus forms with the body of the bone, which is very obtuse at birth, and becomes a right angle after development is completed: 2. to the alterations effected in the body of the bone, by the first and second dentitions, the loss of teeth in the aged, and the subsequent absorption and disappearance of the alveoli.

The Face in general.

Having already noticed the situation of the face, we shall now proceed to examine its dimensions, figure, and regions.

Dimensions of the Face.

In order to form a just idea of the dimensions of the face, it is necessary to examine a skull cut vertically from before backwards (as in *fig.* 22.). We then perceive that the face is comprised within a triangular space, which is bounded above by an irregular line that separates it from the cranium; in front by the face, properly so called; and below by a line passing below the symphysis menti. If a line be drawn above the inferior maxilla, and under the arch of the palate, when prolonged backwards, it will be in the plane of the foramen magnum; for the cranium having much less depth in front than behind, a horizontal line, which touches the cranium behind, is separated from it in front by the entire height of the upper jaw.

The *vertical diameter*, which extends from the frontal protuberance to the chin, is the longest of all the diameters of the face. It gradually diminishes from before backwards. The *transverse diameter* is of considerable extent in the situation of the cheeks, but diminishes above and below this point. The *antero-posterior diameter* stretches above from the nasal spine to the basilar process; below it is greatly contracted; and at the level of the chin only measures the thickness of the symphysis.

With regard to the dimensions of the face as a whole, we shall only refer to what has been already stated concerning the inverse proportion of the area of the cranium, and that of the face in different species of animals.*

The face represents a triangular pyramid, and offers for consideration three surfaces or regions; an *anterior*, a *superior*, and an *inferior*.

* Vide of the cranium in general; of the facial angle of Camper; the occipital angle of Daubenton, and the measurement of Cuvier, p. 60.

Anterior or *Facial Region.*

The numerous anatomical differences which this region presents, form distinctive characters, not only of different nations, but also of different individuals.

It is bounded above by the forehead, below by the base of the inferior maxilla, and laterally by a line which passes along the external orbital process, the malar bone, and the ridge which separates the canine fossa from the tuberosity of the maxilla. In this region we observe, *in the median line*, the nasal eminence, a transverse suture formed by the union of the proper nasal bones with the os frontis, the *fronto-nasal suture;* below this suture the *nose*, a pyramidal eminence, narrow above or at its root, broad below or at its base, and formed by two bones which are united together by juxta-position in the median line, and to the ascending process of the superior maxilla externally. Below this eminence, is the *anterior orifice of the nasal fossæ*, which has the form of a heart on playing cards, and presents at the bottom the anterior nasal spine, and below this a vertical suture, *the maxillary*, the interval which separates the middle incisor teeth, the opening of the mouth, and the symphysis menti. *On each side*, we find the opening or base of the orbit, directed obliquely outwards, of an irregular square form, and presenting above, the *supra-orbitary foramen;* below, the *infra-orbitary foramen;* on the outside, the *fronto-jugal suture ;* and on the inside, the *fronto-maxillary suture.* Below the opening of the orbit is the canine fossa, then the alveoli and teeth of the two jaws, the external oblique line, the mental foramen, and the base of the inferior maxilla.

Superior or *Cranial Region.*

This region is so united with the inferior surface of the cranium, that the skull and the superior maxilla form only one piece, and cannot be removed from each other. It presents *in the median line* counting from behind forwards, the articulation of the vomer with the sphenoid, in which articulation there is a mutual reception of parts, the sphenoidal crest being received between the laminæ of the vomer, and these in their turn being lodged in corresponding fissures in the sphenoid; the articulation of the vomer with the posterior edge of the perpendicular plate of the ethmoid; the articulation of this perpendicular plate with the nasal spine of the frontal bone; and the articulation of this spine with the proper bones of the nose. *On each side*, proceeding from within outwards, we observe, 1. the roof of the nasal fossæ, formed behind by the inferior surface of the body of the sphenoid; in the middle by the cribriform plate of the ethmoid; and in front by the posterior surface of the nasal bones: 2. more externally the base of the pterygoid processes, the articulation of the palate bone with the sphenoid,. the pterygo-palatine canal, and the spheno-palatine foramen: 3. the articulation of the lateral masses of the ethmoid with the sphenoid behind, and with the frontal bone in front: 4. the articulation of the internal orbital process of the frontal bone with the os unguis: 5. the articulation of the nasal notch of the frontal bone with the ascending process of the superior maxilla, and the proper bones of the nose: 6. more externally still the roof of the orbit, bounded externally by the articulation of the frontal with the malar bone and the sphenoid, and by the sphenoidal fissure: 7. the anterior surface of the great wing of the sphenoid, which forms the largest portion of the external wall of the orbit: 8. outside the orbit, the zygomatic arch.

Inferior or *Guttural Region.*

This region forms part of the pharynx and cavity of the mouth. It presents from behind forwards: 1. a vertical portion: 2. a horizontal portion: and 3, another vertical portion.

The *vertical portion* (*fig.* 21.) exhibits in the median line the posterior edge of the septum narium, formed by the vomer; the posterior extremity of the articulation of the vomer with the sphenoid (*o*, *fig.* 21.); and the posterior nasal spine. On each side, the *posterior opening of the nasal fossæ* (*k o, y*) which is quadrilateral, longer in its vertical than in its transverse diameter, and formed internally by the vomer, externally by the pterygoid process (*r*), above by the sphenoid united with the palate bone, and below by the palate bone. More externally is the *pterygoid fossa* (*r*), formed by the sphenoid, and a small part of the palate bone. Still more externally, we find a deep fossa, or rather a large space bounded internally by the external plate of the pterygoid process and the tuberosity of the maxillary bone, and externally by the ramus of the inferior maxilla: it is known by the name of the *zygomatic fossa*.

The *horizontal portion* is the *arch of the palate* (*i x y*, *fig.* 21.). It is of a parabolic form, extremely rough, and in the fresh state covered by the palatine mucous membrane. It is constituted by the palatine processes of the maxillary bones (*x*), and by the horizontal portions of the palate bones (*y*), and presents in consequence a *crucial suture*, at the central point of which the vomer is attached: hence the piece of anatomical nicety which consisted in asking at what part of the skeleton it is possible to touch five bones at once with the point of a needle. The arch of the palate is pierced by several foramina; we find here the inferior opening of the *anterior palatine canal* (1), which is single below, but double above, so as to open into each nostril separately; the *posterior palatine canals* (2), which open at the posterior and external part of the arch of the palate; and a *groove* which runs along the external edge of the arch, and lodges the posterior palatine vessels and nerves at their exit from their canals.

The *third portion* is also vertical; it presents 1. in the median line, the suture of the two superior maxillary bones, the interval between the middle incisor teeth of each jaw, the symphysis menti, and the genial processes: 2. on each side, the posterior surface of the alveolar border of the upper jaw, and the two rows of teeth which lie across each other like the blades of scissors in the middle, but meet posteriorly: 3. the posterior surface of the inferior maxilla, the internal oblique line, the sublingual and sub-maxillary fossæ, and lastly the base of the inferior maxilla.

Zygomatic or *Lateral Regions.*

These regions are bounded above and on the outside by the Zygomatic arch; above and on the inside by the transverse ridge which separates the temporal from the zygomatic fossa. They present first a plane surface formed by the ramus of the inferior maxilla; when this part is removed, we observe the *zygomatic fossa*, the superior wall of which is formed by the inferior surface of the great wing of the sphenoid, the anterior by the maxillary tuberosity, the internal, by the outer plate of the pterygoid process, and the external by the ramus of the inferior maxilla. The posterior and inferior walls are wanting.

At the bottom of this fossa, between the maxillary bone and the anterior surface of the pterygoid process, is a large vertical fissure, named by Bichat the *pterygo-maxillary fissure;* this opening leads into a sort of fossa, denominated by the older anatomists *bottom of the zygomatic fossa*, and by Bichat *spheno-maxillary fossa*, which it is important to study carefully, because five foramina or canals open into it, viz. three behind; the *foramen rotundum*, the *vidian* or *pterygoid*, and the *pterygo-palatine* canals. A fourth on the inside, the *spheno-palatine*, and a fifth below, the superior orifice of the *posterior palatine canal*.

Lastly, the spheno-maxillary fossa presents, at the union of its superior with its anterior wall, the *spheno-maxillary fissure* (*fig.* 21, before 3), which on the one hand makes an acute angle with the sphenoidal fissure (or *foramen lacerum superius*), and on the other a right angle with the pterygo-maxillary fissure. The spheno-maxillary fissure, which is traversed solely by some nerves and vessels, is

formed internally by the maxillary and palate bones, externally by the sphenoid, and at its anterior extremity, which is very broad, it is completed by the malar bone.

Cavities of the Face.

The study of those bones which we have been engaged in examining, has made us acquainted with the existence of a great number of cavities, which considerably augment the size of the face, and multiply its internal surfaces, without proportionally increasing the weight.

All the cavities of the face may be reduced to three principal; viz. 1. the orbital cavities: 2. the nasal fossæ, of which all the sinuses are dependencies: and 3. the buccal cavity or mouth.

The Orbits.

These cavities, two in number, have the form of quadrangular pyramids, the axes of which, prolonged backwards, would intersect each other in the situation of the sella turcica. It should, at the same time, be remarked, that the internal wall of the orbit does not participate in this obliquity, but is directed straight from before backwards. We have to consider in each orbit, a superior, an inferior, an external, and an internal wall; four angles which correspond to the intersection of these surfaces; a base and an apex.

The *superior wall*, or *roof of the orbit*, formed by the frontal bone in front, and by the orbital or lesser wing of the sphenoid behind, is concave, and presents from before backwards, 1. towards the outside, the lachrymal fossa: 2. on the inside, the slight depression in which the pulley for the superior oblique muscle is attached: 3. the suture between the lesser wing of the sphenoid and the orbital plate of the frontal bone: 4. the foramen opticum.

The *inferior wall*, or *floor*, forms a plane inclined outwards and downwards, and presents from before backwards, 1. the infra-orbital canal: 2. a suture which marks the union of the malar bone with the superior maxilla: 3. the orbital surface of the superior maxilla: 4. a suture which marks the union of the superior maxilla with the palate bone: 5. the orbital facette of the palate bone.

The *external wall*, formed by the sphenoid and the malar bone, presents an almost vertical suture, which indicates internally the spheno-jugal suture.

The *internal wall* formed by the os unguis, the ethmoid, and the sphenoid, presents two vertical sutures; in front, that which unites the os unguis to the ethmoid, and behind, that which unites the ethmoid to the sphenoid. In front of these sutures is the *lachrymal groove*, formed by the union of the os unguis and the ascending process of the superior maxilla: at the lower part of this groove we find the wide and very oblique orifice of the nasal canal or duct, which opens into the middle meatus of the nose, and establishes a direct communication between the orbital and nasal cavities.

Of the four angles, two are superior and two inferior. Of the two superior, one is internal, the other external. The *external superior angle* presents the sphenoidal fissure behind; and the inner aspect of the spheno-frontal and fronto-jugal sutures.

The *internal superior angle* presents the suture of union of the frontal bone with the ethmoid behind, and with the os unguis in front. The orifices of the two internal orbital foramina are seen in the situation of this suture.

Of the two *inferior angles* the *external* presents the spheno-maxillary fissure, a portion of the malar bone, and the opening of the jugal canal. The *internal* presents an uninterrupted horizontal suture, which unites in front the maxillary bone to the os unguis; more posteriorly, the maxillary bone, and then the palate bone, to the ethmoid. The *base of the orbit* is cut obliquely from within

outwards, and from before backwards; its vertical diameter is, for the most part, quite perpendicular to the horizon; but is sometimes rendered slightly oblique by the projection of the frontal sinuses. At the *apex* of the orbit is the union of the sphenoidal, the spheno-maxillary, and pterygo-maxillary fissures.

The Nasal Fossæ.

These fossæ are two in number, separated from each other by a vertical septum directed from before backwards; they are situated in the middle of the face, and are prolonged into the interior of several of the bones of the face and cranium by means of the cavities called *sinuses*. To describe their situation more exactly, we may say, that they are placed below the anterior and middle part of the base of the cranium, above the cavity of the mouth, between the orbits, and the canine and zygomatic fossæ of each side. In order to have an exact idea, either of the dimensions or the shape of the nasal fossæ, it is necessary to have recourse to horizontal and vertical sections: of which the latter should be made both from before backwards and from side to side.

With regard to their dimensions the nasal fossæ (see *figs.* 22. and 37.) present, 1. a vertical diameter, larger in the middle than before or behind: 2. a transverse diameter much shorter than the other two, and gradually contracted * from the lower to the upper part, on account of the obliquity of the external wall: 3. an antero-posterior diameter, which measures the whole of the interval between the anterior and posterior openings of the nares.

The nasal fossæ have a horizontal direction, but are nevertheless slightly inclined backwards and downwards; this is caused by the sloping of the inferior wall and the obliquity of the body of the sphenoid, which forms part of the superior wall. They are irregular cavities, and have four walls, — a superior, an inferior, an internal, and an external, and two orifices, an anterior and a posterior.

The *superior wall* or *roof of the nasal fossæ* presents a concavity looking downwards; it is formed, 1. in front by the proper bones of the nose, and in a small degree by the nasal spine of the frontal bone: 2. in the middle, by the cribriform plate of the ethmoid: 3. behind, by the body of the sphenoid. In this wall are two transverse sutures, namely: before, the suture which indicates the union of the nasal and frontal bones, and behind, that which marks the union of the ethmoid and sphenoid. At the back part of this wall the opening of the sphenoidal sinus is seen.

The *inferior wall* or *floor*, much broader but shorter than the superior, presents a transverse concavity, it is directed from before backwards, and slightly from above downwards, which arrangement concurs in determining the obliquity of the nasal fossæ. It is formed, in front by the superior maxilla, behind, by the palate bone; a transverse suture marks the union of these bones. Near its anterior extremity, and at the side of the median line, the floor of the nasal fossæ shows the superior orifice of each branch of the anterior palatine canal (*g*, *fig.* 22. and *o*, *fig.* 37.).

The *internal wall* (see *fig.* 22.) formed by the septum, is generally flat, but sometimes concave or convex, according as it is bent to one or the other side.†

We find here the suture which indicates the union of the vomer with the perpendicular plate of the ethmoid (3 4, *fig.* 22.); the septum in the skeleton is deeply notched in front, and this notch (1 4 8) which is formed above by the perpendicular plate of the ethmoid, and below by the vomer, is occupied in the fresh state by a cartilage, called the cartilage of the septum.

* This progressive contraction of the nasal fossæ from below upwards, and the obliquity of the external wall, ought to be remembered during the introduction of instruments into the nose.

† Sometimes the deviation of the septum is so considerable that the internal touches the external wall, and consequently there is great difficulty in the passage of the air. This circumstance has given rise in some cases to a suspicion of the existence of polypus.

The *external wall* (*fig.* 37.), remarkable for its anfractuosities, is formed by the ethmoid (*b c*), the os unguis, the palate bone (*m y*), the superior maxillary (*s u o*), and the inferior turbinated bone (*d*). It presents from above downwards, 1. the *superior turbinated bone, superior concha*, or *concha of Morgagni* (*b*), in front of which is a rough square surface; 2. the *superior meatus* (between *b* and *c*), at the back part of which we find the spheno-palatine foramen (*n*), and the opening of the posterior ethmoidal cells; 3. below the superior meatus, the *middle turbinated bone*, or *middle concha* (*c*); 4. below, the *middle meatus* (between *c* and *d*), at the back of which is the opening of the maxillary sinus already described (*see* maxillary bone, *fig.* 25.): and in front, the infundibulum (*s*, *fig.* 37.) which leads into the anterior ethmoidal cells; 5. the *inferior turbinated bone*, or *inferior concha* (*d*); 6. the *inferior meatus* (*m o*), in which we find the *inferior orifice of the nasal canal*.

fig. 37.

The anterior and posterior openings of the nasal fossæ have been described with the anterior and inferior regions of the face.

General Development of the Face.

The development of the face is not effected solely by an equable increase of its dimensions; for certain regions are at one period of life predominant, at another period relatively smaller, which circumstances give rise to very characteristic differences of form at different ages.

State of the Anterior Region of the Face at different Periods of Life.

In the fœtus. The upper part of the face shows a remarkable predominance, dependent upon the early development of the frontal bone and the great capacity of the orbits.

The middle portion, or the superior maxilla, on the contrary, is very much contracted by the absence of the maxillary sinus and canine fossa; the vertical dimensions of the superior maxilla and of the palate bone are so small, that the edge of the orbit and the alveolar border are almost contiguous. We should mention here that the prominence of the alveolar border, which still incloses all the germs of the teeth, is the principal cause of the absence of the canine fossa. Lastly, the inferior maxilla is contracted in its vertical diameter, like the superior, and, like it, presents a decided prominence in front, by reason of its inclosing the germs of the teeth in the alveoli. The inclusion of the dental germs also, by causing the alveolar border to project, produces a degree of obliquity downwards and backwards of the symphysis; to these causes of the small extent of the vertical dimension of the face, we must add also the inconsiderable height of the ethmoid at this period.

The transverse dimensions of the face are very considerable at the level of the orbits; at the lower part of the face on the contrary, they are proportionally much less than in the adult.

The characteristics, then, of the face of the fœtus are, 1. the smallness of its vertical dimension; 2. the predominance in size of its upper over its lower part.

In the adult, the development of the maxillary sinus, the widening and vertical extension of the alveolar arches, give to the face the expression which characterises it at that period of life.

In the aged, the loss of the teeth, and the disappearance of the alveolar edge, partly restore to the face the expression which it had in the fœtus; but the elongation and prominence of the chin, which from the diminution of the

vertical diameter approaches the nose, and the symphysis of which is now oblique from behind forwards and downwards, impress upon it a peculiar character. The obliquity of the chin just mentioned, is precisely the reverse of that which exists in the fœtus.

State of the Lateral Regions in different Ages.

These regions undergo the fewest changes of all; for if on the one hand, the development of the maxillary sinus tends to increase the prominence of the maxillary tuberosity in the adult, on the other, the inclusion of the dental germs in the superior maxilla, during fœtal life, compensates for the want of the sinus.

State of the Posterior Region of the Face at different Ages.

In the *guttural portion*, this region presents in the fœtus and the infant the following circumstances:—the posterior borders of the rami of the jaw are very oblique, instead of being almost vertical, as in the adult; the pterygoid processes and the posterior nasal openings are also directed very obliquely downwards and forwards, instead of vertically, on account of the absence as yet of the maxillary sinus, which during its development carries them backwards. From the obliquity of the posterior border of the ramus of the jaw, it follows that the articular surface of the condyle which surmounts it looks backwards instead of upwards.

In the *horizontal* or *palatine portion*, the inferior region of the face has proportionally less extent from before backwards than in the adult, on account of the obliquity of the pterygoid process, and the slight development of the maxillary sinus. We perceive then how great an influence the varying conditions of these sinuses exercise over the whole configuration of the face, at the different periods of life.

It may be easily conceived that the cavities of the face must undergo important changes, during these alterations in the shape of the face which we have been describing, The most remarkable is the tardy development of the nasal fossæ compared with that of the orbits. It may even be said that they proceed in an inverse ratio. The orbital cavity, intended to receive the globe of the eye which is already highly developed at the time of birth, is of great capacity. This magnitude it owes entirely to the rapid growth of the frontal and sphenoid bones; because the malar bone and the superior maxilla contribute but little towards it, and the height of the ethmoid is so small, that the vertical diameter of the orbit, which depends upon that of the ethmoid, is less considerable than its transverse diameter. The nasal fossæ, which are very small in the fœtus, gradually acquire an increased extent of surface, by the growth in height of the ethmoid, the palate bone, the superior maxillary, and the vomer, and by the augmented size of the turbinated bones; and their surface is still further extended by the enlargement of the maxillary, sphenoidal, and frontal sinuses, and the ethmoidal cells. The development of the frontal sinus, it may be observed, is owing chiefly to the separation of the two tables of the bone, the anterior of which is almost always thrown forwards, the posterior remaining stationary. There are, however, some examples on record, in which it was evident that the sinus was formed almost exclusively by the retrocession of the posterior table.

THE THORAX, OR CHEST.

The sternum.— Ribs.—Costal cartilages.—The thorax in general.—Development.

THE thorax (θώραξ, the chest) is a sort of bony cage intended to contain and protect the principal organs of respiration and circulation. The parts which enter into its composition are twelve dorsal vertebræ behind, the *sternum* in front, and twelve flexible bones, named *ribs*, on each side. We have already described the dorsal vertebræ, and have now therefore only to notice the sternum and the ribs.

The Sternum (*a b c, fig* 38.).

The sternum, so named from the Greek word στέρνον, the breast, is a kind of flattened, symmetrical bony column, which occupies the anterior and middle part of the thorax. It is situated between the ribs, which support it like props. The clavicles, and through them the upper extremities, rest upon its upper part as a basis, during their movements. The sternum is not immoveably fixed in its place; it is raised and depressed as we shall point out in describing the mechanism of the thorax.

The length of the sternum, which is proportionally smaller in the female, than in the male, varies from 5¼ to 7½ inches. At its upper part its breadth is from 1½ to 2 inches; it then becomes contracted, then again expands, and terminates below in a very narrow extremity. Its thickness above is about 6 lines; at its lower part it is much thinner, never exceeding 3 lines.

With regard to figure, the sternum was compared by the ancients to the sword of a gladiator, and from this have arisen the denominations given to its various parts. The upper part (*a*), which is broadest, has been called the *handle* (*manubrium*); the middle part (*b*), the *body* (*mucro*); and the lower extremity (*c*), the *point; xiphoid appendix* (*processus ensiformis*). This division of the bone into three parts has been retained by some modern anatomists, who describe the three pieces of the sternum separately as so many distinct bones. We shall adhere to it only, however, in speaking of the development of the bone.

The sternum presents two surfaces, two borders, and two extremities.

1. The *anterior* or *cutaneous surface* is slightly convex, and forms an oblique plane downwards and forwards; it presents three or four projecting transverse lines, which are traces of the union of the original pieces of the bone, and divide it into surfaces of unequal size. The line which marks the union of the first two pieces of the bone is the most remarkable; it causes a projection of variable size in different individuals, which has been sometimes mistaken for a fracture or exostosis. At the lower part of this surface, we find in some subjects a *foramen* which perforates the bone: sometimes in place of this foramen there is a considerable aperture, to which much importance has been attached, as affording a proof of the primitive separation of the bone in the median line. The existence of this opening explains how purulent matter, deposited behind the sternum, may in certain cases make its way outwards without any absorption of the bone. The anterior surface of the sternum is covered by the skin, and an interlacement of very numerous aponeurotic fibres.

2. The *posterior, mediastinal*, or *cardiac surface* (*a b c*), is slightly concave from above downwards, and presents, in young subjects, lines (*e e*) corresponding to those which occupy the anterior; but all which, excepting the one between the first and second pieces of the bone, are effaced at a more advanced age. This surface is in relation with many organs contained in the chest, and especially the heart, in front of which the sternum forms a kind of shield.* At the lower part of this surface are several nutritious foramina.

* This use of the bone is exemplified in many animals which are provided with a sternum, *though they have* no ribs; for example, the frog.

3. The *borders*, very thick, and sinuous, present seven articular cavities (*d d*, &c.), separated from each other by semilunar notches, which are longer ibove than below, where the facettes closely approach one another. The uppermost of these seven cavities is shallow, triangular, and at an early age be-comes ingrained with the cartilage of the first rib; those which follow are leeper, angular, and situated at the extremities of each of the lines (*e e*) above nentioned; they are all intended to articulate with the cartilages of the first even ribs. When examined in a dried specimen, they appear more angular and leeper in proportion to the youth of the subject.

4. The *superior* or *clavicular extremity* is the broadest and thickest part of he whole bone, presenting a notch, transversely concave, which bears the iame of *fourchette* (*f*) of the sternum (or *semilunar notch*); on each side (*g g*) s an oblong articular surface, concave from without inwards, convex from efore backwards, articulated with the clavicle, and surrounded with inequa-ities for the insertion of muscles and ligaments. It frequently happens that he two clavicular facettes are not at the same height; a fact which was no-iced by Morgagni, and which I have attributed to the unequal wearing of the wo articular surfaces.

5. The *inferior* or *abdominal extremity* is formed by the *xiphoid appendix* (*c*) ξίφος, a sword), called also *xiphoid* or *ensiform cartilage*, because it often re-nains cartilaginous to adult age. In length, shape, and direction, it presents umerous varieties: it is frequently bifid, sometimes pierced by a foramen, nd is occasionally bent forwards, or to one side, and in certain cases much epressed: its summit gives attachment to an aponeurotic structure, called the inea alba; behind, it indirectly corresponds with the stomach, which rests pon it when the body is placed in a prone position.

Connections. The sternum articulates with sixteen bones; viz. fourteen ribs hrough the medium of their cartilages, and the two clavicles.

Structure. It consists of two very thin compact laminæ, with an inter-ening spongy substance, the cells of which are very large, and have very elicate parietes: it is one of the most spongy bones of the body, and to this ircumstance the frequency of its diseases is doubtless attributable.

Development. The sternum is one of the slowest bones in its ossification; p to the sixth month of fœtal life the broad cartilage of which it is com-osed exhibits no bony points. It is also, of all the bones, the one in which the henomena of ossification proceed with least regularity. For the sake of sim-licity we shall study in succession the development of the three parts which re have indicated, under the names of manubrium, body, and xiphoid appendix.

1. *Ossification of the manubrium.* This part of the bone sometimes presents single nucleus, rounded, and transversely oblong; sometimes it presents two uclei, and in this case they may be either placed one above the other, or side y side. In the former case the uppermost nucleus is the larger; in the latter, oth may be symmetrical and of equal size, or what is far more common they ay be of unequal magnitude. Lastly, the manubrium occasionally presents ore than two osseous points. Albinus found three in one subject and four a another.

It should be remarked, that in the case of plurality of osseous points, the rgest are generally situated above: the exceptions to this rule are very rare. he osseous points make their appearance from the fifth to the sixth month of etal life.

2. *Of the body.* The osseous nuclei which enter into the composition of the ody of the sternum have generally a rounded form when they are single, and re situated in the median line; when they exist in pairs, or are placed late-lly, they are more elongated, but smaller, and appear to represent only the alf of one of the single nodules. These different osseous points are always arranged as to be situated between two costo-sternal articulations, so that a rtion of the sternum is developed in each of the intervals comprised between

two ribs. The last piece is the only exception, being common to the articulation of the sixth and seventh ribs.

If there be more osseous points than one in an intercostal space, these, as Albinus has remarked, are invariably placed laterally, not one above the other.

There are, therefore, four primitive pieces in the body of the sternum, and each of these is sometimes formed by one point of ossification; at other times by two lateral points.

The following is the order in which the ossification of the body of the sternum proceeds: the two upper pieces first appear from the fifth to the sixth month of fœtal life; the third is visible at the sixth month; the fourth most commonly makes its appearance after birth, but sometimes towards the end of gestation.

In the ossification of the body of the sternum, we more frequently find examples of two symmetrical nodules placed on opposite sides of the median line, than in the development of the manubrium.

Union of the points of ossification of the body. In considering the union of the different parts which compose the body of the sternum, it is necessary to make a distinction between the *lateral conjunction*, that is, the union of the osseous points which are situated on each side of the median line, and the *vertical conjunction*, or the union of the pieces of the sternum properly so called. The lateral conjunction, or the union of those osseous germs which form a pair in the same interval, always precedes the vertical conjunction. The vertical conjunction, or the union of the pieces of the body of the sternum together, commences with the two inferior portions. After this union, the body of the bone consists only of three parts. The second piece then unites with the lower; the sternal foramen is found sometimes at the junction of these last mentioned parts, sometimes at the place where the two lateral points of the fourth and of the third portion of the body are united. The first piece of the body is not united to the two others until from the twentieth to the twenty-fifth year.

It should be observed that the union of the divisions of the body of the sternum takes place precisely in the inverse order of their appearance. In fact, the appearance of the osseous points proceeds from above downwards, their union from below upwards; a fact which verifies an assertion formerly made, viz. that the order of development of osseous points is not always correlative to the order of conjunction.

3. *Ossification of the appendix.* This is generally accomplished by one nodule: sometimes there are two, and then they are rarely symmetrical. The process commences in the upper part of the cartilage, and very rarely extends through the whole. The time of appearance of the osseous point is extremely variable; sometimes it is visible towards the third or fourth year; sometimes not until the twelfth or even the eighteenth year.

In adult age, the sternum is composed of the three parts, the development of which I have just noticed, and which the ancients considered and described as distinct bones. From the fortieth to the fiftieth year, and sometimes later, the appendix becomes united to the body, which very rarely joins the manubrium; when such is the case, the union is more apparent than real; for if the bone be cut vertically, the articulation is apparent, under a very thin layer of osseous matter.

From what has been said of the numerous varieties of ossification, it will be evident that it is impossible to assign to this bone a limited number of osseous points. To those which have been noticed, I would add two others, described by Béclard under the name of *supra-sternal points*, which I have seen once only in the sternum of an adult, in the form of pisiform nodules, placed on each side of the semilunar notch of the sternum.

The Ribs (1 to 21, *fig.* 38.).

The ribs (*costæ*, from *custodes*, as if, according to the explanation of Monro, they were the guardians of the organs of the chest) are osseous arches stretched from the vertebral column to the sternum. Their posterior four-fifths consist of bone, the anterior fifth is cartilaginous. The osseous portion is the rib, properly so called; the cartilaginous portion is named the costal cartilage.

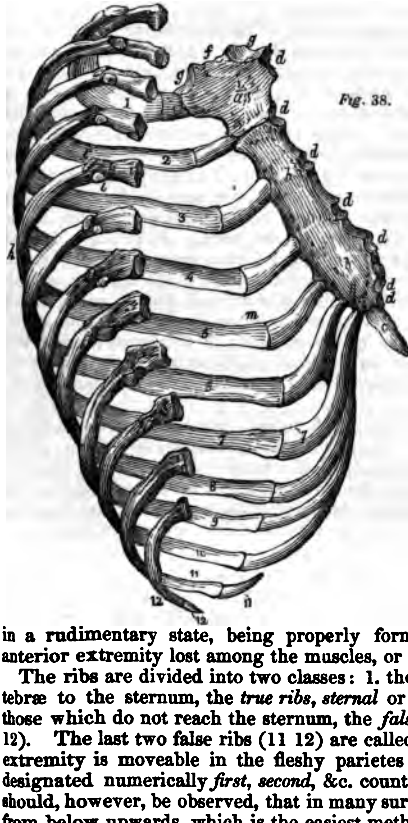


Fig. 38.

The ribs are 24 in number, 12 (1 to 12) on each side. Sometimes there are 26, thirteen being on each side, and then these supernumerary ribs are formed either from a part of the transverse process of the seventh cervical vertebra, or of the transverse process of the first lumbar, which affords an evident proof of the analogy existing between these parts. Sometimes, but more rarely, there are only 22 ribs, an anomaly pointed out by Galen. In this case, we sometimes find two adjacent ribs united throughout their entire length, sometimes the first rib in a rudimentary state, being properly formed posteriorly, but having its anterior extremity lost among the muscles, or united to the second rib.

The ribs are divided into two classes: 1. those which extend from the vertebræ to the sternum, the *true ribs, sternal* or *vertebro-sternal ribs* (1 to 7); 2. those which do not reach the sternum, the *false, asternal* or *vertebral ribs* (8 to 12). The last two false ribs (11 12) are called *floating*, because their anterior extremity is moveable in the fleshy parietes of the abdomen. The ribs are designated numerically *first, second*, &c. counting from above downwards. It should, however, be observed, that in many surgical works, the ribs are counted from below upwards, which is the easiest method on the living subject.

The ribs have certain *general characters* which distinguish them from all other bones, and certain *proper characters*, by which one is known from another.

General Characters of the Ribs.

The ribs resemble flattened bony arches, of about six lines in breadth, and one in thickness, and of lengths varying according to their situation. The first rib is almost horizontal, and the others in succession slope gradually more obliquely from behind forwards, and from above downwards, their anterior extremities being on a much lower plane than the posterior. Considered with regard to their axes, *i. e.* their absolute direction, the ribs represent portions of a circle which successively increase to the eighth, and diminish again to the twelfth: their curvature is not regular, the posterior part representing the segment of a much smaller circle than the anterior. They are generally *twisted* upon themselves,

so that their two extremities cannot rest at once upon the same horizontal plane. The point where this torsion exists, is marked on the convex surface by an oblique projecting line, called the *angle* (*h*) *of the rib;* but it is not correct to consider the angle of the rib as resulting from this torsion; it appears to me simply intended for muscular insertions.

The ribs have a body and two extremities. The posterior or vertebral extremity is thicker than the rest of the bone, whence it has received the name of *head* (*i*) (*capitulum costæ*), and presents two half surfaces (*c c*, *fig.* 39.), of which the upper is smaller than the lower, separated by a horizontal ridge. These two facettes articulate with corresponding surfaces on the bodies of the dorsal vertebræ (*d d*, *fig.* 39.). The head is supported by a constricted portion, the *neck* (*k*, *fig.* 38.), which is flattened from before backwards, and is the weakest part of the bone. It presents behind some inequalities which correspond to the transverse process of the dorsal vertebra below. Externally to the neck is an eminence known as the tubercle (*l l*) of the rib; it is divided into two parts, which are united at an angle, viz. an internal and inferior portion (*l*) smooth and convex, which articulates with the transverse process of the vertebra below the particular rib examined; and an external rough portion (*l*), which gives attachment to ligaments. The tubercle is in general most prominent in the upper ribs.

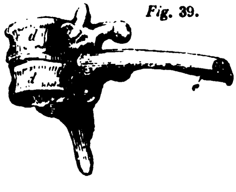


Fig. 39.

That part of the rib which is included between the head and the tubercle (*neck*, *cervix*), is directed from within outwards, and slightly from above downwards, so as to reach the summit of the transverse process of the vertebra below. Beyond the tubercle the rib still follows the same direction for not more than fifteen lines; it is then bent decidedly forwards. The situation of this curve, which corresponds with the torsion of the edges above mentioned, is at the angle of the rib. The interval which separates the tuberosity from the angle is the thickest and strongest part of the rib.

The rest of the rib, which is before the angle, becomes broader and thinner, and is directed forwards, so that, as Haller expresses it, the line which it describes represents in some measure the tangent of the posterior curve. The anterior extremity (*m*) has a hollowed oval facette for receiving the cartilage. Besides the objects we have already described, we observe, near the anterior extremity of the rib, an oblique line analogous to that which forms the angle, but much less marked. This line may be considered as forming the anterior angle of the ribs, and like the posterior it is intended for muscular insertions.

From what has been said, we perceive that the ribs present, 1. a posterior extremity or *head*, supported by a *neck;* 2. an *anterior extremity* united to the *costal cartilage;* 3. a *body*, having an *external* or *cutaneous surface*, which is convex; and an *internal* or *pulmonary surface*, which is smooth and concave; a *superior edge* which is curved, thick, and rounded; and an *inferior edge*, which has a greater curvature than the superior, is thin and sharp, and marked by a groove or furrow on the inner surface, called the *groove of the ribs* (*z*, *fig.* 39.), which receives and protects the intercostal vessels and nerves. Lastly, the ribs have a double curvature, one of the surfaces, another of the edges; this last is the curvature of torsion.

Connections. The ribs are articulated behind with the dorsal vertebræ, in front with the costal cartilages.

Structure. The external aspect of a rib resembles a long bone; but the internal conformation is analogous to that of flat bones. The compact and spongy substances are so distributed, that these bones enjoy a certain degree of flexibility, with great power of resistance. In young subjects, the compact substance is in excess; in the aged and in certain diseases the opposite is the case; hence the extreme fragility of these bones, which are then broken by the least effort.

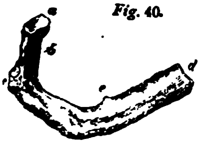
Development of the ribs. The ribs are among the earliest developed of the bones; the ossification of their bodies commencing from the fortieth to the fiftieth day after conception. They are developed by three osseous points; one primitive, and two epiphysary. The primitive point by itself forms the body of the bone. Of the two epiphysary points, one is intended to form the head of the rib, the other the tubercle. They appear from the sixteenth to the twentieth year, and they unite with the rest of the bone about the twenty-fifth year. These epiphysary points do not exist in the two lower ribs, which consequently have only one point of ossification.

Special Characters of different Ribs.

The differential characters of the ribs have reference, first, to the length, which increases gradually from the first to the seventh, and diminishes again to the twelfth; secondly, to the curvature, the four upper ribs being parts of much smaller circles than the rest, and thus forming the summit of the cone of the chest, while the lower ribs constitute its base; and lastly, to certain peculiarities of conformation in the first, second, third, eleventh, and twelfth ribs, which require special description.

The *first rib* (1, *fig.* 38. and *fig.* 40.) is the shortest, and proportionally the broadest of all the ribs, thus forming an imperfect lid to the bony case, which constitutes the thorax. Its edges are curved, but its surfaces are flat. The curve, which it describes, forms part of the circumference of a much smaller circle than any of the other ribs. The posterior extremity has a small head with a single convex facette (*a*, *fig.* 40.), supported by a long thin and cylindrical neck (*b*). The tubercle (*c*) is very prominent; it occupies the external border, and gives an angular appearance to this rib. The anterior extremity (*d*) is broader than that of any other ribs. Of the two surfaces, one is directed upwards and slightly outwards, the other downwards and a little inwards. The superior surface (*fig.* 40.) has two depressions separated by a tuberosity (*e*). The anterior corresponds to the subclavian vein; the posterior to the artery of the same name. The tuberosity which separates them gives attachment to the anterior scalenus muscle. The internal edge (*a e d*) is concave, the external (*a c d*) is convex and has no groove. The first rib has neither a curvature of torsion, nor an angle; so that the whole of it can rest upon the same horizontal plane. The superior surface presents also near its anterior extremity a depression which appears to result from pressure by the clavicle, which I have seen, in some cases, immediately articulated with this bone.

Fig. 40.



The *second rib* (2, *fig.* 38.) preserves many of the characters of the preceding, but differs essentially in its length, which is at least double; it belongs to a much larger circle: it has no curvature of torsion, and can rest upon the same plane with its two ends; the angle is scarcely visible. The external surface is directed upwards; it presents in the middle a very rough eminence for the attachment of the serratus magnus muscle. The internal surface looks obliquely downwards; near the tubercle it has a very small groove.

The *third rib* (3, *fig.* 38.) differs from the second by its great length, by the presence of the angle, and by a curvature of torsion sufficient to prevent the two ends from resting at once upon the same horizontal plane.

The *eleventh* and *twelfth ribs* (11 12, *fig.* 38.) differ from all the others by the following characters: 1. they form segments of much larger circles than any of the others; 2. their heads have only one articular facette, and this is flattened; 3. they have no neck, properly so called; 4. they have no tubercle; 5. they have no groove; 6. they have a very thin and pointed anterior extremity. These two ribs differ from each other only in length, the twelfth being the shorter.

The Costal Cartilages (1' to 12', *fig.* 38.).

The flexibility and elasticity of the ribs is partly owing to their structure, but more especially to the costal cartilages which prolong them in front. There are twelve costal cartilages distinguished numerically as first, second, third, &c.; they are separated from each other by intervals, which are very considerable at the upper part of the thorax, but gradually diminish as we proceed downwards: it is not very uncommon to meet with thirteen cartilages on one side, at other times there are only eleven. We sometimes find two cartilages, which are joined together, and articulated with the sides of the sternum; when there are thirteen cartilages, the supernumerary one generally exists between the third and fourth ribs; it is thin and as it were rudimentary; it does not form the continuation of any rib, and terminates insensibly in the muscles. The first seven cartilages (1 to 7) articulate immediately with the sternum; and hence the name of sternal given to the ribs with which they are connected. Of the other five cartilages, the last two (11 12) have no connection with those that precede them; and from this circumstance the name *floating* has been given to the last two ribs.

General Characters of the Costal Cartilages.

All the costal cartilages are flattened like the ribs, and precisely resemble in breadth and thickness the bones to which they are attached. The external end is received into a cavity hollowed out in the anterior extremity of the rib: their internal or sternal extremity, which is much narrower than the external, is angular, and articulates with the corresponding angular facettes of the sternum. Their anterior or cutaneous surfaces are slightly convex, and covered by the muscles of the anterior region of the trunk, to many of which they give attachment. Their posterior or mediastinal surfaces are slightly concave. Their superior and inferior edges bound the intercostal spaces, and give attachment to the muscles of the same name. They are altogether distinct from articular cartilages, and have a peculiar tendency to ossify, this process taking place partly on the surface, and partly from within outwards.

Differential Characters of the Costal Cartilages.

The costal cartilages increase in length from the first to the seventh and sometimes to the eighth, which in this case articulates with the sternum; they diminish in length from the seventh to the twelfth. This difference depends on the circumstance that the osseous parts of the upper ribs terminate anteriorly in a line directed obliquely from above downwards, and from within outwards, and that the sternum is only about half the length of the lateral wall of the thorax, so that only the first four or five cartilages could join this bone, did not the others bend upwards, so as to reach its sides or join the lower edge of the cartilage above; the first three cartilages alone therefore follow the same direction as the bony rib. The *first cartilage* differs from all the others by its shortness, its thickness and breadth, and its tendency to ossify; it is almost always bony in the adult; it is often continuous with the sternum, but is sometimes only contiguous. The *second* and *third costal cartilages* cannot be distinguished from each other, but they differ from the rest, in being joined at right angles with the sternum, in not being bent, and in being as broad at their sternal as at their costal extremities. The *fourth cartilage* becomes bent upwards after having followed the direction of the rib for a little way. The length and curvature of the cartilages of the fifth, sixth, and seventh ribs, progressively increase: the seventh is at least three inches long, while the fifth is not more than thirteen or fourteen lines; their inner ends become successively narrowed, so as to correspond with the diminishing cavities on the edges of the sternum; the borders of the fifth, sixth, seventh, and eighth costal cartilages articulate together, and present for this purpose articular facettes supported by eminences. The

cartilages of the eighth, ninth, and tenth ribs gradually diminish in length; externally they have the same breadth as the rib, and decrease as they pass inwards so as to terminate by a pointed extremity, which is applied to the lower edge of the rib above. The cartilages of the eleventh and twelfth ribs are extremely short, especially that of the twelfth, which is only a few lines in length; their internal free extremity loses itself, so to speak, in the substance of the abdominal parietes, so that they are altogether unconnected with the other cartilages.

The Thorax in general.

The sternum, the ribs, and the whole dorsal region of the vertebral column, form the frame-work of a large visceral cavity, the *thorax*, intended to contain and protect the chief organs of respiration and circulation. It occupies the upper part of the trunk, between the thoracic extremities; its boundaries are very well defined above, but below there is not any line of demarcation in the skeleton, between the cavities of the thorax and abdomen; or rather the bony thorax is common to the thoracic and abdominal viscera. We shall see afterwards that these two cavities are separated from each other by a moveable and muscular septum, called the diaphragm.

With regard to capacity, the thorax holds a middle place between the cavity of the cranium and that of the abdomen. In each individual, the capacity of the thorax is exactly proportional to the volume of the lungs; and as, in general, voluminous lungs co-exist with a highly developed muscular apparatus, it follows that the size of the thorax is no equivocal sign of a vigorous constitution. The thorax differs much from the abdominal cavity, in regard to its extensibility, being only capable of very limited alternate movements of dilatation and contraction. In the structure of the thorax we find the twofold condition of solidity and mobility in so perfect a degree, that the frame-work of which it is composed is equally fitted to serve as a protecting structure and a respiratory apparatus. This limited dilatability contrasts, on the one hand, with the almost indefinite extensibility of the abdominal cavity, and on the other with the absolute want of extensibility in the cranium.

We should form a very incorrect idea of the dimensions and shape of the thorax, if we were to judge of them by its external aspect while still covered by the soft parts, and surrounded by that species of girdle which is formed by the shoulder round its upper part; for we should then conclude it to be a truncated cone, with the base above. On the contrary, when the surrounding parts are removed, the thorax represents a cone, the base of which is in precisely the opposite direction, that is below. The height of the thorax cannot be measured with exactness, because it varies according to the depression or elevation of the muscular septum, which intervenes between the thoracic and the abdominal cavities. We can only say, that the bony frame-work should be divided into two parts, a superior or supra-diaphragmatic, which belongs to the chest properly so called, and contains the lungs and heart; and an inferior, which forms part of the cavity of the abdomen, and contains the liver, the spleen, the kidneys, the stomach, the duodenum, and part of the colon. It should be also remarked, that the supra and sub-diaphragmatic portions of the thorax constantly vary in their respective proportions; and that these variations of height principally take place at the sides, the middle remaining always nearly the same. The transverse diameters increase rapidly from the upper to the lower part of the thorax. The same is true of the antero-posterior diameters, and these also sensibly increase opposite the concavity of the dorsal region of the spine. The antero-posterior diameters are much greater laterally than in the median line, where they are diminished by the considerable projection of the bodies of the dorsal vertebræ. This shortness of the antero-posterior diameters between the sternum and the vertebral column, is in proportion to the small size of the heart, which is situated in this region, as compared with that of the lungs which occupy the sides.

Antero-posterior flattening. The cone represented by the thorax, is flattened from before backwards. This flattening appears to be connected with the existence of the clavicle; for we meet with it in all animals provided with this bone, while in those in which it does not exist, the flattening is lateral, *i. e.* from one side to the other.

The shape of the thorax is subject to many varieties, as respects different individuals, age, sex, &c. Of the individual varieties some are compatible with health; others are pathological and constitute malformations, the history of which belongs to the subject of diseases of the chest. Sometimes they are congenital; at other times they are the result of accidental circumstances which have modified the primitive conformation.

In some subjects the lateral exceeds the antero-posterior flattening, and the sternum is prominent, as we habitually see it in the thorax of phthisical patients.

Many individual varieties of conformation of the thorax are the effect of frequently repeated, or permanent compressions exercised on the bony cavity. I have seen infants, in whom the thorax was perfectly well-formed at birth, but had been deformed and flattened on the sides by pressure from the hands of the nurse. If there be, in fact, a time when the slightest external pressure may be productive of permanent deformity, it is during the first years of life. The effects of a strong and permanent constriction are also manifest in a very evident manner, in the alterations of the form of the thorax consequent upon the use of stays. This species of constriction affects principally the lower part of the chest; so that the fifth, sixth, seventh, eighth, ninth, and tenth ribs are pressed forwards and inwards, because the length and flexibility of their cartilages allow them to yield readily; and all the viscera which correspond to this species of girdle, undergo very marked alterations in their direction, and even in their figure and position. Thus, the liver, the spleen, and the stomach, are forced upwards and compress the lungs, which, in their turn, are pushed to the upper part of the chest, and have a tendency to pass considerably beyond the level of the first rib: 2. the stomach becomes more oblique: 3. the transverse arch of the colon is often forced downwards; the pregnant uterus acquires an oblique direction. In an old female, whose thorax was so contracted below as to present the appearance of a barrel, and bore witness to the use of a very tight corset, the cartilage of the seventh rib, on the right side, was in contact with that of the opposite rib; the xiphoid appendix was strongly depressed, and pushed behind the cartilages of the seventh and eighth ribs which touched each other. Some varieties of conformation depend upon deviations of the vertebral column; they evidently belong to pathological anatomy, and need not occupy our attention. In the female, the chest resembles a cone with a larger base but of less height than in the male.

There are certain varieties at different ages, which will be noticed in the history of the general development of the thorax.

As the thorax does not form a regular cone, when we speak of its *axis* being directed obliquely from above downwards, and from behind forwards, we only refer to its anterior wall; the posterior and lateral being altogether devoid of this obliquity.

We shall now consider in detail the external and the internal surface of the thorax; the inferior circumference or base, and the superior circumference or summit, resulting from its conical form.

External Surface of the Thorax.

On this surface we find an anterior, a posterior, and two lateral regions.

The *anterior* or *sternal region*, much wider below than above, forms a plane inclined from above downwards, and from behind forwards, and more or less projecting according to the general conformation of the thorax. It presents, 1. in the middle, the cutaneous surface of the sternum; 2. on the sides, the series of articulations of the cartilages of the ribs with the sternum; 3. the

costal cartilages, those being the longest which appertain to the lower ribs; 4. between the cartilages, certain intervals named *intercostal spaces;* 5. externally to the cartilages, an oblique line running from above downwards, and from within outwards, and marking the series of articulations of the costal cartilages with the ribs; 6. still more externally, another oblique line, which has not been pointed out, and which is formed by the anterior angles of the ribs; it corresponds in obliquity with the chondro-sternal line, and forms the boundary of the anterior region.

The *posterior* or *vertebral region* presents, in the median line, the series of dorsal spinous processes; on the sides, 1. the vertebral grooves; 2. the series of dorsal transverse processes; 3. their articulation with the tubercles of the ribs; 4. a series of surfaces of which the lower are the largest, and which are comprised between the angle and the tubercle of each rib; 5. lastly, an oblique line running from above downwards, and from within outwards, formed by the posterior angles of the ribs.

The *lateral* or *costal regions* resemble a sort of curved grate, more convex behind than in front, and showing the series of ribs and intercostal spaces in the same manner as the anterior and posterior regions. They increase in width from above downwards, and form a sort of inclined plane, with a curved surface, and obliquely directed from above downwards, and from within outwards. The first two intercostal spaces are both the broadest and the shortest; the third and fourth are broader in front than behind; the following are of almost uniform width through their whole extent: on the whole, the breadth of the spaces diminishes from above downwards, or, as Bertin remarks, the edges of the lower ribs are almost in contact. The last two intercostal spaces form the only exception, for they are nine lines in width, while those in the middle of the chest are only about four. It should, moreover, be remarked, that the intercostal spaces are broader in front than behind; a fact which may be easily shown by comparing the distance which separates the anterior extremities of the first and second ribs, with that which intervenes between their posterior terminations. The length of the intercostal spaces increases from the first to the sixth; it then diminishes to the two last, where it is very small.

Internal Surface of the Thorax.

This surface, like the external, is divided into four regions The *anterior region* exactly resembles the anterior region of the external surface, with this difference only, that it is concave instead of being convex.

The *posterior region* presents, 1. in the median line, the dorsal portion of the spinal column, which like an incomplete septum forms a projection in the interior of the thoracic cavity, and divides it into two equal parts; 2. on the sides, two deep grooves which are contracted above, but gradually enlarge towards the lower part. These grooves, which lodge the posterior convex portions of the lungs, exist only in the human subject; they allow part of the weight of the body to be thrown backwards,—an arrangement which is very advantageous for preserving the equilibrium in standing, and is a proof that man is destined to the erect posture.

The lateral regions form an inclined plane on the inside, resembling that which exists on the outside, only they are concave instead of being convex.

Superior and Inferior Circumferences.

The *superior circumference* or *summit* is narrow in comparison with the inferior, and slopes obliquely from above downwards and forwards; it is wider transversely than in the antero-posterior direction, and resembles the shape of a heart on playing cards. The circumference of this opening is formed in front by the upper end of the sternum; behind, by the first dorsal vertebra; on the sides, by the first ribs and their cartilages. This opening, which is contracted in its dimensions by the clavicles, gives passage to the following organs; the

trachea, the œsophagus, the thoracic duct, the large arteries and veins of the head, neck, and thoracic extremities, the apex of the lungs, and several muscles of the neck.

The *inferior circumference* or *base*, is very wide, at least four times larger than the preceding, and, like it, broader transversely than from before backwards. It presents, 1. in front, a wide notch, the borders of which are formed by the cartilages of the seventh, eighth, ninth, and tenth ribs, but are incomplete between the tenth and eleventh, as also between the eleventh and twelfth; at the apex of this notch is the ensiform cartilage; 2. behind, we find on each side of the vertebral column a notch of much smaller dimensions than that in front; it is caused by the great obliquity of the twelfth rib, which forms an acute angle with the spine. The inferior circumference of the thorax is connected with muscles, by numerous attachments.

The great mobility enjoyed by the lower aperture of the thorax, which, as we have seen, is subjected to alternate movements of dilatation and contraction, contrasts remarkably with the almost absolute immutability of the superior aperture. The lower opening presents certain varieties in dimension which are observed chiefly during inspiration, or are occasioned by accidental causes of dilatation, such as pregnancy or the accumulation of fluids in the abdominal cavity. This variability of its dimensions has reference to the compressibility and dilatability of the abdominal viscera. Such an alteration at the upper opening would have caused serious inconvenience by compressing the trachea and the vessels.

General Development of the Thorax.

The shape and dimensions of the thorax vary considerably at different periods of life; it is of great importance to be well acquainted with these, because they bear constant relation to changes in the organs contained within the cavity.

One of the most remarkable characteristics of the fœtal thorax, is the predominance of the antero-posterior over the transverse diameter; at this age, we find the sternum very far separated from the spine, and forming a considerable projection in front. This arrangement coincides with the largely developed state of the heart, and an organ denominated the thymus gland, which are both situated in the middle of the thorax; and also with the small size of the lungs, which are situated laterally. Another marked feature in the chest of the fœtus is the absence, or at least the slight depth, of those grooves which we have described as peculiar to man, and intended to lodge the posterior edge of the lungs. The absence of these pulmonary grooves produces, as a necessary consequence, a want of those external projections on the back of the thorax, which we find in the adult corresponding with the grooves on the interior These two characteristics, viz. the predominance of the antero-posterior diameter, and the absence of the grooves, both depend on the same cause, viz. the slight degree of curvature of the ribs in the fœtus.

At a more advanced period the curvatures increase, the posterior grooves are gradually developed, the antero-posterior diameter is diminished, and the transverse proportionally increased, so that there is less difference in the absolute capacity of the thorax than would at first sight appear, for the differences we have noticed are in a great measure referrible to the comparative predominance of one or other diameter. We should also remark, that in the fœtus, the vertical diameter, particularly at the sides, is much shorter on account of the unexpanded state of the lungs, and the elevation of the diaphragm by the abdominal viscera.

The two circumferences likewise present remarkable differences. In the fœtus, the superior opening has a greater extent from before backwards than transversely, which is precisely the opposite of what is observed in the adult. The inferior aperture is extremely wide in every direction; and this accords with the large size of many of the abdominal viscera at this age, and particularly of the liver.

At birth, there is a sudden enlargement of the chest, because the access of air increases the lungs to a double or threefold extent, which up to this period were much contracted. At puberty, the thorax participates in the great development which the respiratory apparatus undergoes. It is at this time also that malformations of this cavity most frequently become obvious. In adult age, the thorax still grows, but in an almost insensible manner.

In the aged, the different pieces of the sternum become united by osseous union; the cartilages are ossified; the thorax has a tendency in some degree to form only one piece, which does not permit the different parts to move upon one another.

THE LIMBS.

The *limbs* are those long appendages of the body which are connected with the trunk only by one end, and which are completely isolated from it in the rest of their extent. They are also denominated *extremities*, because they are the parts which are most distant from the centre of the body. They are four in number: *two superior*, or *thoracic*, so called because they are directly connected with the thorax; and *two inferior*, or *abdominal*, because they are continuous with the abdominal cavity. These last are intended to support the weight of the body like two pillars, and to transport it from place to place: the thoracic limbs are intended to seize objects or to repel them. The extremities present in their structure certain general circumstances which are essentially characteristic. We shall particularly notice the following:—

1. As regards their form. The bones of the extremities differ in many respects both from those of the trunk and those of the head. They generally have the appearance of cylindrical and elongated levers, superimposed so as to form a column, the parts of which are movable upon each other.

2. The continuity of the extremities with the trunk is established by means of osseous zones or girdles, viz. the shoulder for the thoracic limbs, the pelvis for the abdominal.

3. The bones of the extremities diminish in size and length from the proximal to the distal, or free end.

4. The number of the bones in the limbs augments, as we proceed, towards their free extremity.

5. As a necessary consequence of the augmented number of bones, and of their progressively diminished size, the articulations become more numerous and smaller towards the distal end of the limb.

The thoracic and abdominal extremities being constructed upon the same fundamental type, we should never forget, in describing them, that they have numerous analogies, while, at the same time, we notice the differences in each which are connected with its peculiar office.

THE SUPERIOR OR THORACIC EXTREMITIES.

The shoulder.— Clavicle.— Scapula.— The shoulder in general.— Development.— Humerus.— Ulna.— Radius.— The hand.— The carpus and carpal bones.— The metacarpus and metacarpal bones.— The fingers.— General development of the superior extremities.

The thoracic extremities are divided into four parts; which, proceeding from the central towards the distal end, are, 1. the shoulder; 2. the arm; 3. the fore-arm; 4. the hand.

The Shoulder.

The *shoulder*, situated at the posterior and lateral part of the chest, is composed of two bones, which form by their union a sort of angular lever with a horizontal and a vertical arm. The horizontal arm is represented by the *clavicle*; the vertical, by the *scapula*.

The Clavicle (*fig.* 41.).

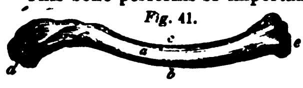


Fig. 41.

This bone performs so important an office in the mechanism of the thoracic extremity that, upon its presence in a certain number of animals, and its absence in others, the extremely important distinction between claviculated and non-claviculated animals has been founded.

The *clavicle*, so called from its supposed resemblance to a key, occupies the superior and anterior part of the thorax, and forms the anterior portion of the shoulder; it is placed horizontally between the sternum, which is its fulcrum, and the scapula, the movements of which it follows. Its length varies in different individuals, and more particularly in the different sexes; in the female it is generally longer than in the male. It is a long bone, and forms one of a pair, and is consequently asymmetrical; its inner end (*e*, *fig.* 41.) which is the larger, is rounded; its outer end (*d*) is flattened from above downwards, and it enlarges progressively from without inwards like a cone. Its direction should be carefully studied. Proceeding from its outer end, which is very thin, we find it describing a curve with the concavity forwards (*d a*); it then changes its direction, and describes a much larger curve with the concavity looking backwards (*a e*). The clavicle therefore has two alternate curvatures, resembling an italic *S*, an arrangement which has the advantage of giving strength to the bone, since each curve becomes the seat of a decomposition of forces which greatly diminishes the violence of shocks directed against it from without inwards.

The clavicle may be divided into a *body* and *extremities*.

The *body* (*a*) presents two surfaces, one superior, and one inferior; and two borders, an anterior and a posterior.

The *superior surface* (*a*) of the body, is placed almost immediately under the skin, and offers an extensive and ill-protected surface to the action of foreign bodies; this is one of the causes of the great frequency of fractures of this bone. This surface is covered by the skin, the platysma myoides muscle, and numerous filaments of the cervical plexus of nerves.* Hence, direct blows upon the clavicle are accompanied with severe pain, on account of the compression of the nerves of this plexus. We find on this surface, near its inner end, a tubercle for the insertion of the sterno-mastoid muscle; it has also some inequalities for muscular attachments on the outside.

The *inferior surface*, broad externally, and narrow internally like the preceding, is marked by a groove running longitudinally, and lodges the subclavian muscle. Near the inner extremity of this surface, there is sometimes a facette which articulates with the first rib. Near the outer end there is a very rough tuberosity, and an irregular line directed obliquely from within outwards, and from behind forwards: they are both intended for the insertion of strong ligaments which unite the clavicle and the scapula. The internal third of this surface corresponds to the first rib, which it embraces and crosses at a very acute angle. The middle third corresponds to the first intercostal space, from which it is separated by the brachial plexus, and the axillary vessels; the external third is in relation to the coracoid process and the articulation of the shoulder with the arm.

The *anterior border* (*b*) which is thin externally, becomes expanded into a surface towards the inner end; its external third is concave, the two internal thirds are convex. This convexity allows the clavicle to resist like an arch any violence applied directly from before backwards. The external third of this border is rough, but the two internal thirds are less uneven.

The *posterior border* (*c*) is concave in its two inner thirds, and convex and

* It is not uncommon to find the body of the clavicle itself traversed by a nerve of the cervical plexus.

rough in its external third; its relations are very important: the subclavian vein runs along it, and it also corresponds to the subclavian artery and the brachial plexus. From this it may be conceived how dangerous fractures of the clavicle might become, if the sharp end of the fragments should penetrate among the nerves or the vessels; it may also be imagined, how forcible depression of the clavicle, by compressing the vessels which are distributed to the upper extremity, may suspend the circulation there; and, lastly, we can understand how it is easy to apply a ligature to the subclavian artery, by cutting along the middle of the clavicle. There still remains one important relation to be noticed, viz. the propinquity of the apex of the lungs, from which circumstance it becomes possible to ascertain the sonorousness of this portion of the lungs by percussion on the clavicle.

Extremities. The *external* or *acromial end* (*d*) of the clavicle is thin, and flattened from above downwards; it presents a very narrow elliptical facette, which looks downwards and outwards, and articulates with a corresponding surface on the scapula. This is the weakest part of the bone; it lies almost immediately below the skin, and is much exposed to external violence, by which it is sometimes broken.

The *internal* or *sternal end* (*e*), on the contrary, is the thickest and strongest part of the bone, and might with propriety be named the head of the clavicle; it articulates with the sternum, projecting beyond the concave articular surface of that bone in all directions.

There are many varieties both of size and direction in the body and ends of the clavicle. By inspection of the inner or outer ends of the clavicle, even in the living body, we may judge at once whether the individual has been engaged in a laborious manual employment. I have been able from the simple circumstance of a marked preponderance of size in the inner end of the left clavicle, to declare *à priori*, and correctly, that the individual on whom I observed it was left-handed. In some clavicles the inner half resembles a quadrangular pyramid. In the female the clavicle is much more slender, and the curvatures are less pronounced, than in the male: the strength and degree of curvature of this bone are proportionate to the laborious and continued exercise of the upper extremity. It may, therefore, be easily conceived how much importance should be attached in forensic medicine to the characters of a bone, the examination of which would of itself be sufficient to determine whether the body to which it belonged were male or female, and whether the person had been engaged in a laborious manual occupation, or the contrary.

Connections. The clavicle articulates with three bones, the sternum, the scapula, and often with the first rib.

Internal structure. With regard to its structure, the clavicle appears to hold a middle place between the long bones and the ribs; like the first, in fact, it possesses a medullary canal; but it approaches the structure of the ribs in the contracted dimensions of this canal, and the spongy nature of its ends. In examining many clavicles belonging to the collections of the Faculty of Medicine, I was never able to meet with one that had traces of a medullary canal extending throughout its entire length.

Development. The clavicle makes its appearance at a very early period, about the thirtieth or thirty-fifth day: its dimensions, compared with those of the other bones of the thoracic extremities present considerable variations at different ages. In the second month of fœtal life the clavicle has already acquired nearly three lines in length; at this time it is at least four times the length of the humerus and femur. After the commencement of the third month it is not more than half as long again as these bones. At the end of the third month it is still longer than the humerus, which does not exceed it until the fourth month. Lastly, in the fœtus at the full period the humerus does not exceed the clavicle in length by more than a fourth, while in the adult it becomes twice as long.

The clavicle has only one primitive osseous point; from the age of fifteen to twenty-eight years, a complementary or epiphysary point is developed under the form of a very thin plate at the anterior part of the sternal end.

The Scapula (*fig.* 42.).

The *scapula*, or shoulder blade, forms in man the back part of the shoulder; in a great number of animals it constitutes the entire shoulder. Placed like a sort of shield upon the back part of the thorax, for which it serves as a means of protection against external violence, this bone corresponds with the lateral part of the spine, which it approaches or quits according to the different movements of the upper extremity, to which it affords a moveable point of attachment.

Fig. 42.

The scapula is proportionally larger in man than in the lower animals. It is an asymmetrical bone, broad, thin, and triangular, presenting two surfaces, three borders, and three angles.

The *anterior* or *costal surface* is moulded as it were upon the thorax; it is concave, the concavity being named the *sub-scapular fossa*. In this we observe ridges directed obliquely from above downwards, and from without inwards.* In a well formed subject, this surface should be exactly fitted to the surface of the thorax; but when the chest is contracted, as in phthisical patients, the scapula does not participate in an equal degree in this alteration, and there is consequently a disproportion and change of relative position, to such a degree that the scapulæ form a projection behind, and are in some measure detached from the ribs like wings: hence the expression of *scapulæ alatæ*, applied to the external aspect of the shoulder-blades in phthisical persons.

The *posterior* or *superficial surface* (*fig.* 42.) is divided into two distinct parts by a triangular eminence named *the spine of the scapula* (*a*). This spine, situated at the junction of the upper with the three lower fourths of the bone, arises from the posterior surface by a thick edge, which traverses the entire breadth of the scapula; the spine is then directed horizontally backwards, outwards and a little upwards, and presents for our notice an *upper* and a *lower surface*, which form part of the supra-spinous and the infra-spinous fossæ; an *external border* (*c*) short, concave, thick and smooth; and a *posterior border* (*a*), very thick and sinuous, which has at its inner end a triangular smooth surface (*d*), over which the trapezius muscle glides. This border is placed almost immediately under the skin, and may be easily traced in the living subject, even in very corpulent individuals.

Instead of uniting so as to form an angle, the external and the posterior borders of the spine are continued into a process named *acromion* (*e*), (from ἄκρος the summit and ὦμος), because this process forms the highest point of the shoulder. The acromion then forms a continuation of the spine, which appears to be its root. At the place where the spine is continuous with the acromion, there is a contraction, a sort of pedicle, above which the acromion enlarges, and becomes curved into a triangular arch presenting an anterior and a posterior surface, a superior and an inferior edge, a base and a summit. The *posterior surface* of the acromion is convex and rough, and is separated from the skin by fibrous tissue and a synovial bursa. The *anterior surface* is concave and smooth, and corresponds to the shoulder joint. The *upper edge* has a facette

* The direction of these ridges is not parallel with that of the back part of the ribs, but crosses them at an angle; proving, in opposition to the opinion of some of the older anatomists, that the ridges, and the depressions which separate them, are not the result of pressure exercised by the ribs on the anterior surface of the scapula.

which articulates with a corresponding surface on the clavicle; the *lower edge* is convex and rough; the *summit* forms the highest point of the shoulder; the *base* is continuous with the spine; the narrowness of this base or pedicle of the acromion explains the possibility of fractures at this point.

The whole of the posterior surface of the scapula, above the scapular spine, forms the *supra-spinous* fossa (*f*), which is narrow at its outer part, and a little enlarged and shallower at the inner, and is filled by the *supra-spinatus muscle*. All that is below the spine forms the *infra-spinous fossa* (*g*), which is occupied by the infra-spinatus muscle. Towards the outer part, this fossa presents a vertical ridge which marks off a narrow surface, elongated from above downwards, and itself divided by an oblique ridge into two smaller surfaces, the superior (*h*) of which gives attachment to the teres minor muscle, and the inferior (*i*) to the teres major.

Of the *three borders* or *costæ* of the scapula the *internal*, which is also called the *base*, *posterior costa*, or *vertebral border* (*k d l*), is the longest of the three in the human subject; in the lower animals it is the shortest. It is thin, slopes from without inwards in the upper fourth of its extent, and from within outwards in the three inferior fourths, which gives it an angular form. The spine of the scapula meets the base at this angle (*d*).

The *superior* or *cervical border*, or *superior costa* (*k r*), is the thinnest; we observe on it a *notch* (*r*) of variable size, which is converted into a foramen by means of a ligament, and gives passage to the supra-scapular nerve, occasionally also to the vessels of that name

The *external* or *axillary border*, or *inferior costa* (*s l*), is the thickest part of the scapula. It is separated from the thorax by an interval, the extent of which determines the depth of the cavity of the axilla. Its thickness increases from the lower to the upper part, where there is a depression (*s*) from which the long head of the triceps muscle arises.

Angles. Two of the three angles of the scapula are intended for the attachment of the principal muscles belonging to this bone; the third enters into the formation of the shoulder joint.

The *internal angle* (*k*) is that which approaches most to a right angle. In robust subjects it presents a marked impression for the insertion of the levator anguli scapulæ muscle.

The *inferior angle* (*l*) is very acute, and is marked internally by inequalities for the attachment of the serratus magnus. This angle is only covered by the skin and the latissimus dorsi muscle, and is consequently more liable than the other two to fracture from external violence.

The *external* or *glenoid angle* (*m*) is the thickest part of the scapula: it is hollowed into an oval cavity, the long diameter of which is vertical, and the small end of the oval uppermost. This cavity, called the *glenoid cavity* (*m*) of the scapula, belongs to the shoulder joint; it is supported by a contracted portion (*n*) called the *neck* of the scapula, and is surmounted by a strong process (*o*) named *coracoid* from a fancied resemblance to the bill of a raven. This process is directed outwards and forwards like a finger in a state of semi-flexion: its lower surface which looks outwards is concave and smooth, and is curved to correspond with the head of the humerus; its upper surface is convex and rough, and articulates with the clavicle. Its summit is rough, and affords attachment to muscles.

Connections. The scapula is articulated with the clavicle and the humerus.

Internal structure. There is very little spongy substance in the composition of the scapula, as may be well observed in the supra and infra-spinous fossæ, where we can scarcely make use of a file, without breaking through the very thin lamina of compact tissue of which the bone is composed at these points. The spongy tissue occupies the axillary border, the spine, the articular angle, the acromion, and the coracoid process.

Development. The scapula is developed from six points; one primitive for the body of the bone, and five epiphysary or complementary, viz. one for the

coracoid process, two for the acromion, one for the posterior border, and one for the inferior angle.

The osseous point of the body appears towards the end of the second month of utero-gestation in the infra-spinous fossa, under the form of an irregularly quadrilateral plate of bone, on the surface of which we cannot perceive any vestige of the scapular spine. It is not until the third month that this process becomes apparent; and at that period the ossification has made so little progress towards the upper part of the bone, that the spine, which subsequently is situated below the upper fourth of the scapula, is then sufficiently elevated to project beyond the upper part of that bone. The spine is never developed from a separate point, but sprouts as it were from the posterior surface of the bone.

The osseous point of the coracoid process appears sometimes at birth, but generally during the first year.

The osseous germ of the base of the acromion process, which has a rounded form, is developed before the fifteenth year. That of the summit of the acromion does not become visible, until from the fifteenth to the sixteenth year; that is the time at which the coracoid process is united to the body of the bone. It is very variable in its shape, being sometimes like a narrow band, sometimes forming by itself the greatest part of the process.

The osseous point of the inferior angle of the scapula is developed during the course of the fifteenth year.

The osseous point of the vertebral border extends along the whole posterior costa as a long marginal epiphysis, analogous to that which we shall afterwards describe as existing on the haunch bone. It is not formed till the seventeenth or eighteenth year.

The union of these different osseous points does not commence until the fifteenth year, at which time the coracoid process becomes joined to the body of the bone. The other points unite at various periods, which have not yet been determined with much exactness. The osseous point of the vertebral border remains the longest separate of all. The union of all these points is not completed until the time when the growth of the body is terminated.

The Shoulder in General.

Considered as forming only one piece, the shoulder represents a bony girdle intended to serve as a fulcrum to the upper extremities. This girdle is incomplete in front opposite the sternum, and behind in the region of the vertebral column. From this it follows, that the two shoulders are independent in their motions, while the pelvis, which forms an analogous structure for the lower extremities, is a continuous whole, the different parts of which cannot move upon each other. The shoulders are fixed upon the upper part of the thorax, and so greatly increase its apparent dimensions, that the chest, when they are attached, resembles a cone with the base upwards, while in its true shape it is a cone with the base below. The shoulder is moulded exactly upon the thorax in front and behind; on the outside it is separated from it by an interval which forms the apex of the axilla.

The circumstance which principally determines the transverse breadth of the shoulders in the female, is the length of the clavicle — in the male it is the breadth of the scapula. The length of the clavicle and the width of the chest in front and at the upper part in the female, are evidently connected with the large size of the mammæ; and the greater development of the scapulæ in the male evidently corresponds with his greater muscular power.

General Development of the Shoulder.

The development of the shoulder is remarkable for its precocity. For, on the one hand, the considerable length, the well defined form, and the double

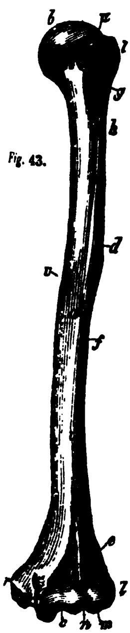
curvature of the fœtal clavicle, at a time when all the long bones are still straight, prove the rapidity with which this part of the skeleton is developed. On the other hand, the size of the scapula, which is already considerable, and the very advanced state of ossification of the part that sustains the glenoid cavity, which enables it very soon to afford a sufficient resistance to the movements of the humerus, equally concur in demonstrating the same fact. This rapid development cannot be attributed to the near vicinity of the heart and great vessels, because the sternum and the cervical vertebræ, which are still more closely approximated to the centre of the circulation, are proportionally much slower in their ossification.

The Arm.

The Humerus (*fig.* 43.).

The *humerus*, or bone of the arm, is situated between the shoulder and the forearm, at the side of the thorax. It is the longest and the strongest of all the bones of the upper extremity. It is proportionally shorter in individuals of the Caucasian or white races, than in the Ethiopian, which in this respect presents some analogy to the Ape tribes. Its direction is vertical, that is, parallel to the axis of the trunk, but with some degree of obliquity downwards and inwards. This obliquity is much greater in the femur, the bone of the lower extremity which corresponds with the humerus. The distance between the humeri is much greater in man than in quadrupeds, corresponding with the different shape of the thorax, which, as we have before observed, is flattened from before backwards in the human subject, and laterally in quadrupeds. The humerus is not curved as regards its axis, but it presents a very marked *curvature of torsion*, which gives rise to a remarkable groove, that lodges the deep artery and the radial nerve as they turn round the bone in a part of their course.

Fig. 43.



The humerus is a long asymmetrical bone, presenting for examination a *body* (*a*) and *two extremities* (*b c*); the upper of these is rounded, and is called the *head* (*b*).

The lower half of the *body of the humerus* is prismatic and triangular; the upper is cylindrical. It has three surfaces *an external*, *an internal*, and *a posterior*, and three edges. *an external*, *an internal*, and *an anterior*.

The *external surface* (*d e*) presents, 1. a remarkable muscular impression, shaped like the letter V, with the point turned downwards; this is the *deltoid impression* (*d*), and is generally situated below the upper third of the bone, but sometimes at the middle: 2. the *groove of torsion* (*f*) directed obliquely downwards and forwards, the depth of which is always proportional to the prominence of the deltoid mark. Below the groove the external surface (*e*) looks forwards, and is slightly concave.

The *internal surface* (*a*) is an oblique plane, looking forwards and inwards; the brachial artery runs along it, and therefore it is of importance to be well acquainted with the obliquity of the surface, in order that when it is necessary to compress the vessel force may be applied in the proper direction. Its upper part which looks forwards, is broader than the lower which is turned inwards. On this surface we observe, 1. the *bicipital groove* (*g*) which will be particularly noticed afterwards,; 2. the principal nutritious foramen (*v*) of the humerus, which passes downwards into the interior*; 3. an obscurely marked impression for the coraco-brachialis muscle.

* There are some varieties in the situation of the nutritious foramen. I have seen it on the external, or even posterior surface of the bone.

The *posterior surface* is smooth, round, and much broader below than above: it is covered by the triceps.

Of the *three edges*, the *anterior* (*h i*) is a rough ridge, round and blunt below, bifurcated above, so as to form the two borders of the bicipital groove (*g*), which is one of the largest and deepest of all the tendinous grooves in the body, and lodges the tendon of the long head of the biceps. The two borders (the external (*h*) and the internal (*k*) are very prominent and rough, and afford attachments to powerful muscles. It should be remarked that the anterior branch of the V, represented by the deltoid impression, is blended with the anterior edge of the bicipital groove, and greatly increases its prominence.

The other two edges of the humerus, viz. the *external* (*d l*) and the *internal* (*v r*) are blunt and scarcely distinguishable in their upper two-thirds, but sharp and prominent at their lower parts, especially the external edge, which curves forwards and gives attachment to a great number of muscles. This edge is also interrupted in its course by the groove of torsion.

The *lower* or *cubital extremity* (*c*) of the humerus is flattened from before backwards, with a transverse diameter four times longer than the antero-posterior. It presents a series of eminences and depressions arranged in the same transverse line, viz. counting from without inwards, 1. an *external tuberosity* (*l*) called *epicondyle* by Chaussier, which forms a continuation of the outer border, and gives insertion to almost all the muscles on the back of the forearm: 2. the *small head* (*m*) of the humerus (*humeral condyle* of Chaussier), a rounded eminence, bent forwards and oblong from before backwards. The small head articulates with the radius and is surmounted in front by a superficial depression intended to receive the rim of the shallow cup-like cavity on the top of the radius. 3. An articular furrow (*n*) extending obliquely from behind forwards, and from without inwards, and separating the small head from 4. the *trochlea*(*c*) or *articular pulley of the humerus*, which is also directed from behind forwards, and from without inwards, is excavated like the groove of a pulley in its long diameter, and the inner border of which descends much lower than the outer. This trochlea articulates with a corresponding surface on the ulna, and is surmounted in front by a small cavity named *coronoid* (*o*), and behind by a much larger depression, the *olecranoid cavity*. These two cavities, the anterior of which receives the coronoid process of the ulna during flexion of the forearm, and the posterior, the olecranon, during its extension, are only separated from each other by a very thin translucent lamina of bone, which is sometimes perforated, so that they communicate with each other. 5. The *internal tuberosity* or *epitrochlea* (*r*)* which is bent inwards, is much more prominent than the external, forming a projection which can be easily felt under the skin, and gives attachment to almost all the muscles situated on the anterior aspect of the forearm.

The *superior* or *scapular extremity* of the humerus, much larger than the inferior presents, 1. the *head* (*b*), a sphenoidal eminence, forming about one-third of a sphere. It articulates with the glenoid cavity of the scapula, and is bounded in the two upper thirds of its circumference by a circular furrow. The constriction resulting from this furrow has been improperly called the *anatomical neck of the humerus* (*s*). The only part which could possibly be considered as the neck, is a portion of the bone which projects on the inner side, and appears to support the head. It is of importance not to confound the circular constriction which we have mentioned, as being called the anatomical neck, with what is denominated the *surgical neck* (at *k*), which is nothing more than that slightly contracted portion of the bone which supports the whole of its upper extremity. The presence of the anatomical neck of the humerus, and the inclination of the articular surface, cause the axis of this surface to form an obtuse angle with the axis of the rest of the bone. 2. Two other eminences named *greater* (*t*) and *lesser* (*u*) *tuberosities* (*trochiter* and *trochin* of

* Epitrochlea, from ἐπὶ, upon, and τρέχω, to turn. Epicondyle, from ἐπὶ, upon, and κόνδυλος, an eminence.

er), and which might be called the *great* and *small trochanters* of the s: they are separated by the bicipital groove. The smaller, which is , gives attachment to the sub-scapular muscle; the larger which is ex- presents three surfaces, each of which gives attachment to a muscle.

ections. The humerus articulates with the scapula, the radius, and the

ial structure. The two extremities of the humerus are cellular; the is compact. It has a very large medullary canal.

lopment. The humerus is developed from seven points; one for the vo for the upper end, and four for the lower.

irst osseous point appears in the middle of the bone from the thirtieth to ieth day, in form of a small solid cylinder, which progressively extends both extremities. At birth, and during the course of the first year, emities are still cartilaginous. The ossific point of the head of the humerus at the commencement of the second year; and that of the great tube- rom the twenty-fourth to the thirtieth month. It has not in my opinion oved that there is any special point for the lesser tuberosity. The ossifi- f the lower end of the bone commences after that of the upper. At rs and a half an osseous point is developed, corresponding to the small condyle of the humerus; at seven years another nodule appears in the ilea; at twelve years a third point, which forms the inner edge of the .; and lastly, at sixteen years, a fourth point for the epicondyle.

wo points of ossification of the upper end of the bone unite from the o the ninth year. The four points of the lower end are joined together ollowing order: in the twelfth year the two points of the trochlea, in eenth year the trochlea, the epicondyle, and the small head. The two ties are united to the shaft from the eighteenth to the twentieth year. ion of the lower end always precedes that of the upper by one year, h the latter first becomes ossified.

The Forearm.

The Ulna (*fig.* 44.).

ulna, or *cubitus*, so called because it forms the elbow, is situated between the humerus and the carpus, on the inner side of the radius, with which it articulates above and below, but from which it is separated in the middle. It is the longer and the larger of the bones of the fore arm. When the whole limb is in the vertical position, this bone slants a little from above downwards and outwards. It is a long and asymmetrical bone, much larger above than below, prismatic, triangular, and slightly twisted upon itself: it is divided into a shaft and extremities.

The *body* or *shaft* (*a*) of the bone is larger above than below, is slightly curved forwards, and has three surfaces and three edges.

The *anterior surface* (*a*) is broad above, and becomes gradually narrower towards the lower part. On it we observe the nutritious foramen (above *a*), which penetrates from below upwards, *i. e.* in precisely the opposite direction of the nutritious canal in the humerus.

The *posterior surface* (*d*) is slightly convex, and is divided longitudinally by a prominent vertical line into two portions, the inner of which is the broader. The *internal surface* is very broad above, and much smaller at its lower end, which is immediately subcutaneous. It is smooth throughout its whole extent. Of the three edges the *external* (*e*) is the sharpest, especially in the middle; it commences above, below a small articular surface, and is effaced at the lower part of the bone It gives attachment to the interosseous ligament, a sort of fibrous membrane stretched between the radius a. The *anterior edge* (*n f m*) is blunt, and is intended for muscular in-

sertions; towards its lower part it bends slightly forwards, becomes rough, and terminates in front of a pointed eminence called the *styloid process* (*m*): it commences above by a very marked projection (*n*), on the inside of an eminence named the coronoid process of the ulna. The *posterior edge* commences below the olecranon by a bifurcated extremity; it terminates insensibly towards the lower fourth of the bone; this edge may be felt beneath the skin throughout its whole extent.

The *superior* or *humeral extremity* (*b*) of the ulna presents a considerable enlargement; it is hollowed in front into a hook-like cavity, which articulates with the trochlea of the humerus, to the shape of which it is adapted. This cavity, which forms almost half the circumference of a circle, is called the *great sigmoid cavity* (*b g h*) of the ulna, because it has been compared to the letter sigma of the Greek alphabet. It has a vertical branch, which forms the *olecranon process* (*b*), and a horizontal one named the *coronoid process* (*h*). There is a sort of constriction at the place (*g*) where these two branches meet; this is the weakest point of the upper end of the ulna, and is consequently the almost invariable seat of fractures of the olecranon. The *olecranon* (*b*), so named from ὠλένη, the elbow, and κράνον the head, because it constitutes the most prominent part, or head of the elbow, presents, 1. a posterior surface, smooth above, and rough and irregular below, where it gives insertion to the triceps; 2. an anterior or articular surface, divided by a vertical ridge into two lateral parts of unequal magnitude; 3. two borders more or less rough, in different subjects, which afford attachments to the triceps muscle; 4. a base, with the constriction we have before described; 5. the summit having the form of a curved beak, which is received into the olecranal cavity of the humerus during extension of the fore-arm.

The horizontal branch of the sigmoid cavity, or the *coronoid process* (*h*), presents, 1. a rough inferior surface (*i*), on which the brachialis anticus muscle is inserted; 2. a superior surface divided into two unequal parts by a ridge, which is a continuation of that which divides the articular surface of the olecranon; 3. an internal rough edge (*n*), bent inwards, and giving insertion to the internal lateral ligament of the elbow joint; 4. an external edge marked by a small cavity which is oblong from before backwards, and slightly concave in the same direction, and is called the *lesser sigmoid cavity* (*k*) of the ulna: below this small cavity is a rough, triangular, and deeply excavated surface, to which the supinator brevis muscle is attached; 5. an anterior sinuous edge, with a projection or beak which is received into the coronoid cavity of the humerus during flexion of the fore-arm.

The *lower extremity* of the ulna presents a small rounded enlargement (*c*), which has been called the *head of the ulna*. We observe on the outside an articular facette (*l*), convex, and elongated from before backwards, which is received into a corresponding concave surface on the lower extremity of the radius. On the inner side of this head a vertical cylindrical process arises, called *styloid process of the ulna* (*m*), the point of which gives attachment to the internal lateral ligament of the wrist joint. The head of the ulna presents below a smooth surface which articulates with the cuneiform bone, a moveable fibro-cartilage being interposed; it isseparated from the styloid process behind by a groove for the passage of a tendon, and on the inside by a slight irregular depression to which the triangular fibro-cartilage is attached.

Connections. The ulna articulates with the humerus, the radius, and the cuneiform bone.

Internal structure. The shaft of the ulna is compact; the two extremities are cellular, especially the upper, the olecranon process of which resembles a short bone, both in form and structure. Sometimes even, as Rosenmuller has observed, this process constitutes really a short bone, entirely separated from the ulna.

Development. The ulna is developed from three points; one for the shaft, and one for each extremity. The osseous point of the body appears first, from the thirty-fifth to the fortieth day, or a little later than that of the humerus.

At birth, the extremities are entirely cartilaginous; they do not begin to ossify until the sixth year, the lower one having the priority. The coronoid process is formed by extension of the ossific point of the shaft. The nodule of the olecranon appears about the seventh or eighth year. The upper extremity is united to the shaft from the fifteenth to the sixteenth year; the lower from the eighteenth to the twentieth year.

The Radius (*fig.* 45.).

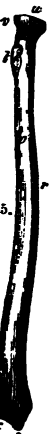


Fig. 45.

The *radius*, so named because it has been compared to the spoke of a wheel, is situated between the humerus and the carpus, on the outside of the ulna, to which it is contiguous above and below, and from which it is separated in the middle by the interosseous space. It is somewhat smaller and shorter than the ulna, and has a vertical direction. It is a long and asymmetrical bone, prismatic and triangular in its shape: its lower end is the larger, and its shaft is slightly curved; it consists of a shaft and extremities.

The *shaft* (*o*), smaller above than below, presents a slight curvature with the concavity looking inwards: this circumstance increases the distance between the radius and ulna, *i. e.* the interosseous space. It has three surfaces, an anterior, a posterior, and an external, and three edges. The *anterior surface* (*o*), narrow above and broad below, presents (above *o*) the orifice of the nutritious canal, which, like that of the ulna runs upwards, or in an opposite direction to that of the humerus. It is somewhat excavated, and gives attachment to many deep-seated muscles of the fore-arm. The *posterior surface* also slightly hollowed, gives attachment to several of the deep-seated muscles on the back of the fore-arm. The *external surface*, convex and rounded, is of equal breadth in almost its whole extent, and presents near the middle a rough surface for the insertion of the pronator teres.

Of the three *edges* one is anterior, the other posterior, and the third internal: the *anterior edge* (*t r s*) is blunt superiorly; it commences below a marked projection, named the bicipital tuberosity, or tubercle of the radius (*t*); from this point it passes obliquely outwards, and terminates below, in front of another eminence called the styloid process (*s*) of the radius. The *posterior edge*, less prominent than the anterior, forms a scarcely perceptible demarcation betweeen the two surfaces which it separates; it is pretty well marked in the middle of the bone, but hardly distinguishable above and below. The *internal edge* (*t y*) is sharp, and has the appearance of a ridge; it commences below the bicipital tuberosity, and extends to a small articular cavity (*y*), on the inner side of the lower end of the bone. This edge gives attachment to the interosseous ligament in its whole extent.

The *superior* or *humeral extremity* (*u*), called also the *head of the radius*, expands in form of a shallow but regularly shaped cup, the cavity corresponding with the small head of the humerus, which it partially receives. It is bounded by a circular border with a vertical articular surface (*v*), varying in breadth in different points, being nearly three lines broad on the inside where it is in contact with the lesser sigmoid cavity of the ulna. The head of the radius is supported by a constricted portion, or *neck* (*w*), of a cylindrical form, and five or six lines in length, which is obliquely directed from above downwards, and from without inwards. At the junction of the neck and body of the radius, on the inside, we see a very marked process, called *bicipital tuberosity* (*t*). Its posterior half is rough, where it gives attachment to the tendon of the biceps; the anterior is smooth and the tendon of the biceps glides over it, before reaching its point of insertion.

The *inferior* or *carpal extremity* (*x*), which is the largest part of the radius, is irregularly quadrilateral. Its lower surface is articular, smooth, concave,

irregularly triangular, and divided by a small antero-posterior ridge into two parts, an internal which articulates with the semilunar bone of the wrist, and an external which articulates with the scaphoid. In the outside of this surface, we observe a pyramidal, triangular process, slightly bent outwards; this is the *styloid process* (*s*) of the radius, shorter and much thicker than the styloid process of the ulna, and like it giving attachment to one of the lateral ligaments of the wrist joint. The circumference of this end of the bone exhibits *in front* some inequalities to which the anterior ligament of the wrist is attached; *behind* and on the *outside*, it is marked by the following tendinous grooves, viz. proceeding from without inwards, 1. an oblique groove on the external surface of the styloid process, which shows the trace of a longitudinal division marking out two secondary furrows; 2. a groove bounded by projecting edges, and subdivided into two secondary ones by a longitudinal ridge, less elevated than the lateral border; 3. a somewhat deeper groove, also divided into two secondary furrows of unequal dimensions, by a very prominent line.*

On the *inside* (*y*), the lower end of the radius is slightly excavated, to articulate with the carpal extremity of the ulna.

Connections. The radius articulates with the humerus, the ulna, the scaphoid and semilunar bones.

Internal structure. The two extremities of the radius are cellular, and are covered by a very brittle layer of compact tissue: the shaft is almost entirely formed of compact tissue, and has a very narrow medullary canal.

Development. The radius is developed from three points, one for the body, and one for each extremity. The osseous point of the body appears some days before that of the ulna; the lower extremity is developed about the second year: the upper at nine years. The upper extremity, which is last in beginning to ossify, becomes united to the body of the bone about the twelfth year, whilst the lower extremity is not joined until from the eighteenth to the twentieth year.

The Hand (*fig.* 46.).

The *hand* is the last part of the upper extremity. It is the organ of touch and of prehension; and as it serves both for purposes which demand great force, and for such as require extreme delicacy, its osseous part is so constructed as to combine great solidity with great mobility. It is composed of twenty-seven bones, exclusive of the sesamoid bones. The hand exists only in man and in the ape; and its importance is so great, that it has been considered by naturalists as establishing a fundamental character of the species. Man alone constitutes the class of bimana, the apes form the class quadrumana; but in the hand of the ape, compared with that of man, we find great inferiority.

Fig. 46.

The hand, considered as part of the skeleton, is composed of five series of small columns. Each series consists of four pieces, excepting the outer one, which has three only. The five series of columns converge so as to unite with a bony mass, composed of eight bones (*a* to *i*) articulated together, and forming by their junction the base of the hand or the wrist. This bony mass is called the *carpus*. The five columns (*k k*), next the carpus, have received the name of *metacarpal bones*; by their union they form the

* In the description of the muscles, we shall point out the tendon which occupies each of these primitive and secondary grooves. All enumerations of this kind, the advantages of which we do not dispute, when the bones and muscles are already known, will find a place in the table at the end of the part devoted to myology. We have noticed here the muscular insertions, because, instead of burdening the memory, they are useful in fixing the attention upon the objects described.

metacarpus, which corresponds with the palm of the hand; lastly, the columns which succeed to the metacarpus form appendages, which are entirely isolated and independent of each other; these are the *fingers*, which are distinguished by numerical names of first, second, third, fourth, and fifth, counting from without inwards, the hand being supine, and the palm turned forwards; they are also known by the following appellations: *thumb*, *index* or *indicator*, *middle*, *ring*, and *auricular* or *little finger*. Each finger is composed of three bones, called *phalanges* (*l m n*), distinguished also successively, from above downwards, by the numerical names of first, second, and third. The third bears also the name of *ungual*, because it supports the nail; the thumb has only two phalanges (*l n*); it is also distinguished from the other fingers, by being on a plane anterior to them.

The form of the hand leads us to consider separately a dorsal, convex surface, the *back* of the hand; an anterior or palmar surface, the *palm* (*fig.* 46.); an external or *radial* edge (*a n*), formed by the thumb; an internal or *ulnar* edge (*c n*), formed by the little finger; a superior, carpal, or *anti-brachial* extremity; and an inferior or *digital* extremity, composed by the ends of the fingers, which, from their unequal length, form a curve with the convexity downwards.

The natural attitude of the hand is that of pronation, *i. e.* the attitude in which it is placed when the bones of the fore-arm, instead of being parallel as in supination, are crossed in such a manner that the lower part of the radius is in front of the ulna. The hand is in this position when laying hold of any thing, or exercising the sense of touch. For facility of description we shall suppose the hand to be in the state of supination, and the palm turned forwards.

The axis of the hand is almost the same as that of the fore-arm.

The Carpus (*a* to *f*, *fig.* 46.).

The *carpus* (from καρπὸς, wrist, κάρπειν, to lay hold of) constitutes the bony structure of the wrist; it is of an oblong form, and almost elliptical transversely. The *anterior surface* (*fig.* 46.) is concave, and forms a deep groove in which the tendons of the flexor muscles are lodged. The *posterior surface* is convex, and in contact with the extensor tendons. They are both traversed by waved lines, which indicate the numerous articulations of the component bones. The *upper border* is convex, and articulates with the radius and ulna; the *lower* is irregular and sinuous, and articulates with the metacarpal bones.

At each of the two extremities of the ellipse represented by the carpus, we observe two eminences which form a projection on the anterior aspect, and contribute to augment the depth of the groove which it forms. The two which occupy the outer edge of the wrist are much smaller than those which are situated on its inner border.

The structure of the carpus is remarkable in this respect; that in proportion to its size, it presents in a given space a much greater number of bones than any other part of the skeleton. It consists in fact of eight bones, and is scarcely one inch in height, and two inches and a half in breadth. These eight bones are arranged in two series, or rows; an *upper proximal* or *anti-brachial* (*a b c d*), and a *lower distal* or *metacarpal* (*e i g f*). Each of these ranges is composed of four bones; counting from the external or radial edge towards the internal or ulnar, they are, in the first row, the *scaphoid* (*a*), the *semilunar* (*b*), the *cuneiform* (*c*), (or *pyramidal*), and the *pisiform* (*d*); in the second row, *trapezium* (*e*), the *trapezoid* (*i*), the *os magnum* (*g*), and the *unciforme* (*f*).

I shall not occupy time in describing successively the six surfaces on each of these bones. By simply explaining the law which regulates their configuration, I shall have the double advantage of avoiding prolixity, and of enabling the student to understand more correctly both their forms and relations.

Bones of the first or Anti-brachial Range.

What I have just said of these bones does not apply to the pisiform, which is distinguished from all the others by particular characters, and merits a special notice. With regard to the rest *, viz. the *scaphoid* (*a*), the *semilunar* (*b*), and the *cuneiform* (*c*), it may be remarked, 1. that they articulate by their upper surfaces with the fore-arm, forming a sort of interrupted condyle, *i. e.* one consisting of several pieces, which is received into the cavity formed by the lower end of the radius and ulna. Each of the bones contributes to form this condyle, by means of a convex surface, consequently, the *superior surface of the bones of the first rank is articular and convex.* 2. They articulate by their *lower surfaces* with the bones of the second rank, which on the inside oppose to them a large head formed by the os magnum and unciform, and on the outside a shallow concavity which corresponds to the trapezium and the trapezoid. In accordance with this, the lower surface of the first row presents on the one hand a concavity which receives the head, and on the other a convexity which corresponds to the cavity.

Three surfaces, belonging to the scaphoid, the semilunar, and the cuneiform unite to form the cavity, which receives the head belonging to the second row. There is, therefore, a broken cavity, *i. e.* one formed of several pieces. The scaphoid being the largest of the bones of the first row, and corresponding by itself to the most convex part of the head of the second row, is more deeply excavated than the two other bones; this has given it the form of a boat, whence the name of scaphoid (σκαφὴ, a boat). The semilunar, which corresponds to the summit of the head, presents from before backwards a concavity which has given it its name; the cuneiform, on the contrary, corresponds to the least convex part of the articular head, and has an almost plane surface.

One bone only, the scaphoid, answers to the concavity formed by the trapezium and trapezoides, and it accordingly presents a convex surface at the point of union. Therefore the *lower surfaces of the bones of the first row are concave, and the lower surface of the scaphoid is partly concave, and partly eonvex.*

3. The bones of the first row of the carpus unite with each other by plane surfaces; those of the scaphoid and semilunar, which join, are very small; the contiguous surfaces of the semilunar and the cuneiform are much larger.

The semilunar and the cuneiform, which occupy the middle of the row, articulate not only with each other, but also with the scaphoid and the pisiform; and each, therefore, has two lateral surfaces, so that the two middle bones of the row have four articular facettes.

The scaphoid, which is the outer bone of the first row, articulates internally with the semilunar, but externally it has a projecting process, which may be easily felt under the skin, and which increases the depth of the anterior groove of the carpus. This eminence constitutes the *external superior process* of the carpus. 4. The bones of the first row forming part of the concavity in front, and of the convexity behind, have their anterior surfaces much smaller than their posterior; both are rough, and serve for the insertion of ligaments.

The pisiform (*d*) is not in the same rank, and has only one articular surface, which unites with the corresponding surface on the cuneiform. The whole of the rest of its surface is intended for the insertion of ligaments and tendons. Its name is derived from its irregularly rounded form. It is placed on a plane anterior to that of the other bones of the first row, and forms the *internal superior process*, which is the most prominent and the most superficial of all the processes of the carpus.

* It is necessary, in order to follow this description, and obtain from it all the advantage which it can afford, to study at the same time an articulated carpus especially one in which the joints are exposed behind, some ligaments remaining in front.

Bones of the second or Metacarpal Row.

The bones of the second row are much larger than those of the first; they form, in fact, the support of the metacarpus. In the first row, the outer bone, namely the scaphoid, is the larger; in the second, the two inner bones, viz. the os magnum (*g*) and unciforme (*f*).

Superior surfaces. We have already stated that the surface of the second row, which articulates with the first, presents a head and a cavity. The head is formed almost entirely by a spheroidal eminence, named *head of the os magnum;* this is supported by a constricted portion, or *neck*, below which is the *body*, the largest part of the bone; this head of the os magnum is truncated at its inner part, and appears to be completed by a portion of the os unciforme. The concavity presented by the bones of the second row is constituted by two bones, the trapezium (*e*) situated on the outside of the carpus, and the trapezoid (*i*) placed between the trapezium and os magnum.

The *inferior surfaces* correspond to the bones of the metacarpus. Taken together, these surfaces form a sinuous and angular line, which by itself would seem to prove the impossibility of dislocation of the metacarpus. The *trapezium* supports the first metacarpal bone; the *trapezoid* the second; the os magnum the third; and the *os unciforme* the fourth and fifth metacarpal bones.

The *posterior surfaces* of the bones of the second row form part of the convexity of the carpus; the *anterior surfaces* are narrower, and correspond with its concavity. There is a process on the anterior aspect at each extremity of the second row; the *internal* belongs to the unciform bone, and resembles a hook, the concavity of which looks outwards, and corresponds with the flexor tendons; the *external* belongs to the trapezium, and forms a much less prominent hook than that of the unciform; on its inside there is a deep oblique groove for the passage of the tendon of the flexor carpi radialis, and it forms the external inferior process of the carpus.

Lateral surfaces. The bones of the second row are joined together by broad plane surfaces, partly articular, and partly non-articular. The two middle bones, viz. the trapezoid and the os magnum, have each two lateral articular surfaces, inasmuch as they are articulated with each other, and since the os magnum is united to the unciforme, and the trapezoid to the trapezium The extreme bones of this row have only one side articular. Each of the middle bones, therefore, has four articular surfaces, a superior, an inferior, and two lateral; each of the extreme bones a superior, an inferior, and one lateral.

Development of the Carpal Bones.

All the bones of the carpus, without exception, are developed from single points. The ossific points appear very slowly; all the bones are cartilaginous at birth. Towards the end of the first year, the cartilages of the os magnum and the unciforme show a bony point in the centre. The osseous point of the cuneiform appears from the third to the fourth year; those of the trapezium and semilunar, from the fourth to the fifth; and those of the scaphoid and the trapezoid from the eighth to the ninth year. The pisiform does not become ossified until from the twelfth to the fifteenth year; in fact, it is the latest to ossify of all the bones of the skeleton.

The Metacarpus (*k k'*, *fig.* 46.).

The five bony columns which rest upon the carpus form the *metacarpus;* they are long bones placed parallel to each other, and constructed on the same model, with very slight differences. Together they form a sort of square grating, the intervals of which are larger, on account of the disproportion ex-

isting between the size of the middle part and the ends of these bones. These intervals are denominated *interosseous spaces.*

The metacarpal bones are five in number, distinguished by the names of first, second, &c. They are not perfectly uniform, either in situation, length, or shape. The metacarpal bone of the thumb, for instance, is situated upon a plane anterior to that which the others occupy; instead of being parallel, it is directed obliquely outwards and downwards, and hence the interosseous space between it and the second metacarpal bone is triangular.

This arrangement is connected with the movement of opposition, which is the characteristic feature of the hand. The metacarpus presents a *palmar* or *anterior surface*, concave transversely, and slightly so from above downwards, which corresponds with the *palm of the hand;* a *dorsal* convex surface, the *back of the hand;* an *external* or *radial edge*, which is short, obliquely directed outwards and downwards, and corresponds to the thumb; an *ulnar* edge, short and straight, which corresponds with the little finger; a *superior* or *carpal extremity*, which presents a very sinuous articular line, to fit the opposite surface of the carpus; and an *inferior* or *digital extremity*, formed by five heads flattened on the sides, and intended to articulate with the corresponding fingers: this lower extremity forms a broken articular line: it is curved, with the convexity downwards, and the first metacarpal bone does not appear to belong to it.

General Characters of the Metacarpal Bones.

The metacarpal bones belong to the class of long bones, having the same form and structure; each consists of a *body* and *two extremities.*

The *body* is prismatic and triangular, and slightly curved, so as to present a concavity on the palmar, and a convexity on the dorsal aspect. Of the *three surfaces* of the body, two are lateral, and correspond to the interosseous spaces; the third is on the back of the hand, and is covered by the tendons of the extensor muscles. Of the *edges*, two are lateral; the third is anterior, and corresponds with the palm of the hand.

The *upper* or *carpal extremity* is large, and has five surfaces, an anterior and a posterior, for ligamentous insertions, and three articular; of the three articular surfaces one is at the end of the bone, and unites with a corresponding surface on a carpal bone; the two others occupy the sides of the extremity, and unite with corresponding surfaces of the adjoining metacarpal bones. In some metacarpal bones the lateral facettes are double on each side. It is necessary to distinguish such of these lateral facettes as are intended to unite with bones of the carpus, between which one of the metacarpal bones is, as it were, wedged, from those which are exclusively intended for the articulation of the metacarpal bones with each other.

The *lower* or *digital extremity* resembles a head flattened on the sides, or a *condyle* oblong from before backwards, with an articular surface of greater extent on the palmar than on the dorsal aspect, *i. e.* admitting of greater flexion than extension; it is marked both internally and externally by a depression, behind which is a rough projection for the attachment of lateral ligaments.

Are there any peculiar characters by which the different metacarpal bones may be distinguished? This question we shall now examine.

Differential Characters of the Metacarpal Bones.

The *first* metacarpal bone (*k'*), is distinguished from the others by the following characters:—it is the shortest and the largest; its body is flattened in front and behind like the phalanges; so that at times it has been looked upon as one of those bones. We shall regard it as belonging to the metacarpus, because it is not only united to the other metacarpal bones by the interosseous muscles, but its inferior or digital extremity also has an exact

resemblance. At the same time, we must acknowledge that there is a circumstance in its development, which tends to establish its analogy with the phalanges. The *carpal extremity* of the first metacarpal bone has a particular form; it is concave from before backwards, and convex transversely, for articulation with the corresponding surface on the trapezium. The characteristic marks then, by which the first metacarpal bone may be recognised, are, *its shortness, its greater size, the antero-posterior flattening of the body, the upper articular surface concave and convex in opposite directions, and the absence of lateral articular facettes.*

There are many distinguishing characters of the *second, third,* and *fourth* metacarpal bones. I shall content myself with saying, that the second and third are known by their greater length, for they exceed the fourth by the whole of their lower extremity; they are also about a third larger and heavier.

The third metacarpal bone is distinguished from the second by its greater size, and, accordingly, it gives attachment to one of the most powerful muscles of the hand, the *adductor pollicis*; it is also known by having two lateral facettes on its upper extremity, while the second has only one.

The *fifth* metacarpal bone (*k*) is the shortest of all excepting the first, from which it is distinguished by its smaller size. It differs from the fourth, which it most resembles; 1. by its shortness; 2. by the presence of an articular facette only on one side of its carpal extremity; 3. by the existence of a very projecting eminence on its inner side, for the insertion of the *extensor carpi ulnaris* muscle.

Connections. The metacarpal bones articulate with each other, with the bones of the carpus, and with the first phalanges of the corresponding fingers.

Internal structure. They have the same structure as other long bones their extremities are cellular, and the shafts compact, with a small medullary canal.

Development. Each metacarpal bone is developed from two points; one for the body and superior extremity, and one for the lower or distal extremity. The first metacarpal bone, which in many respects resembles the phalanges, is similar also in its mode of development. One of its two points appears in the shaft; the other in the upper or carpal extremity, which is the reverse of what takes place in the other bones of the same denomination, and is analogous to that of the phalanges. The ossific point of the body of the metacarpal bone, appears from the fortieth to the fiftieth day. At birth the body is almost completely ossified, but the extremities are still cartilaginous. The bony points of the lower ends of the last four metacarpal bones, and of the upper end of the first, do not make their appearance until the third or fourth year. In general, the upper ends of the last four bones, and the lower end of the first, are ossified by an extension of the shaft; but I have occasionally seen separate germs for each of these, so that every metacarpal bone had three osseous nodules. The union of the lower extremities with the bodies of the four metacarpal bones, does not take place until the eigtheenth or twentieth year; and the same is the case with the ossific point of the upper end of the first metacarpal bone. In those cases where the lower end of the first metacarpal, and the upper ends of the others are formed from special points, their union takes place at a much earlier period.

The Fingers (*l m n*, and *l′ n′*, *fig.* 46.).

The fingers are the essential organs of prehension, and for this purpose have a length, thickness, and mobility, that are very remarkable, when we compare them with the toes, which represent them in the lower extremity. Each finger forms a pyramid composed of three columns placed upon each other; the base of the pyramid corresponds to the metacarpus; and there are two enlargements or knots at the places where the columns (named *phalanges*) unite

together. The three columns which compose each finger successively decrease in size, and are known by the numerical appellations, of *first*, *second*, and *third*. The first, which articulates with the metacarpus, is also called the *metacarpal phalanx* (*l l'*); the second, the *middle phalanx* (*m*); and the third, which supports the nail, the *ungual phalanx* (*n n'*). The thumb alone has only two phalanges, an ungual, and a metacarpal. Chaussier has named the phalanges, *phalange*, *phalangine*, and *phalangette*, counting from the base to the ends of the fingers. These denominations he has found very serviceable in the methodical designation of the muscles of the fingers.

The first Phalanx (*l l'*).

The first phalanx belongs to the class of long bones, and presents to our notice, 1. a body resembling a half cylinder cut along its axis, and slightly curved upon itself, so as to present a concavity in front; the dorsal surface is cylindrical, and covered by the tendons of the extensor muscles; the anterior surface is slightly channelled for the partial lodgment of the tendons of the flexor muscles, its edges are sharp and give attachment to a tendinous sheath, which converts the channel above mentioned, into an osteo-fibrous-canal for the flexor tendons of the fingers; 2. an *upper* or *metacarpal end*, transversely oblong, and presenting a small glenoid cavity for the head of the corresponding metacarpal bone; 3. a *lower end*, forming an articular pulley.

Such are the general characters of the first phalanx, but they are modified in each finger. Thus the phalanx of the middle finger is the longest; those of the index and ring finger come next. The first phalanx of the thumb is the largest in proportion to its length; the first phalanx of the little finger is the most slender; it is also the shortest, excepting that of the thumb.

The second Phalanx (*m*).

The second phalanx differs from the first by its smaller size, and the shape of its upper end, which is fitted to the trochlea on the lower end of the first phalanx. The edges of this phalanx are thick and rough above, where they give insertion to the tendon of the superficial flexor of the fingers.

The thumb has no second phalanx.

The third Phalanx (*n n'*).

This bone, to which so much importance has been attached in natural history*, supports the horny part with which the ends of the digits in animals are armed, and the nails in man. It is shaped thus: the upper end is transversely oblong, exactly resembling the upper end of the second phalanx; from this part it contracts like a cone; afterwards it becomes much enlarged and flattened from before backwards, and ends with the shape of a horse-shoe, rough in front where it supports the pulp of the finger, smooth behind, and indented on the edges. The ungual phalanx of the thumb is much larger than that of the other fingers; that of the middle one is the next in size; those of the index and ring finger are almost equal; and that of the little finger is the smallest. It is very difficult to distinguish the phalanges of the right from those of the left hand.

Development of the Phalanges.

The phalanges are developed from two points; one for the body and lower end, and one for the upper end. This mode of development is common to the first, second, and third phalanges. The osseous point of the body appears

* See the interesting memoir of M. Duméril, intitled *Dissertation sur la dernière Phalange dans les Mammifères*.

successively in the first, second, and third phalanges, from the fortieth to the fiftieth day. The order of succession is not subjected to any certain rules. Bony points are found at the same time in the ungual and metacarpal phalanges, and prior to those of the middle phalanges. The ossific points of the upper ends of the phalanges appear successively in the first, second, and third phalanges some time after birth, from the third to the seventh year. The epiphysary point of the third phalanx is generally developed before that of the second. The epiphyses do not join the bodies of the bones until from the eighteenth to the twentieth year.

General Development of the Superior Extremity.

The thoracic limb in the fœtus and the infant is remarkable for its dimensions, which are proportionally much greater than in the adult. This early development and size are particularly evident when compared with the slow development of the lower limb; the resulting disproportion is in an inverse ratio of the age, that is, it is greatest in early life. The thoracic limb of the fœtus differs from that of the adult in many other respects besides dimensions. Thus, the two extremities of the humerus are proportionally much larger and altogether cartilaginous, though the difference does not appear to me so great as has been imagined. The lower end of the bone is especially remarkable for the size of the small head, which forms a very marked protuberance in front, and projects considerably beyond the pulley or trochlea. In the fore-arm, the upper end of the radius is situated much farther forwards than in the adult; which agrees with the position of the small head of the humerus. This circumstance merits careful notice, because it is one of the predisposing causes of dislocation of the head of the radius forwards, the ligament which keeps it back being scarcely able to overcome its tendency in that direction. For the same reason, displacements of the head of the radius are much more frequent in the infant than in the adult.

The carpus, almost completely unossified at birth, is composed of the same number of cartilages as there are bones afterwards. The metacarpus, on the contrary, is ossified long before birth, but this rapid development, common to the whole thoracic extremity, is most remarkable in the phalanges.

Bichat appears to me to have greatly exaggerated the changes which take place in these bones during the progress of age. I am certain that the torsion of the humerus, and the curvatures of the radius and ulna, and also the interosseous space, exist equally in the new-born infant as in the adult, and in almost the same proportions.

THE INFERIOR OR ABDOMINAL EXTREMITIES.

The haunch. — Os coxæ. — The pelvis. — Development. — Femur. — Patella. — Tibia. — Fibula. — The foot. — The tarsus and tarsal bones. — The metatarsus and metatarsal bones. — The toes. — Development of the lower extremities. — Comparison of the upper and lower extremities. — Os hyoides.

The inferior or abdominal extremity is divided, like the superior, into four parts, viz. the *haunch*, the *thigh*, the *leg*, and the *foot*.

The Haunch.

The *haunch*, which is analogous to the shoulder, is composed of only one bone, the os coxæ or os innominatum. Although the haunch bones are united with the sacrum to form the pelvis, they alone are analogous to the shoulder, for the sacrum only forms the same part with reference to the lower extremity, that the dorsal vertebræ constitute for the upper.

The Os Coxæ, or Os Innominatum (figs. 47 and 48.).

The *haunch bone*, called also *os coxæ*, from *coxa* the haunch, occupies the lateral and anterior parts of the pelvis. It is the largest of all the broad bones of the skeleton. It is asymmetrical, very irregular in its figure, and twisted upon itself, so that it appears to be composed of two portions; one superior, triangular, shaped like a wing, and flattened from without inwards; the other inferior, and flattened from before backwards. These two parts are united by a contracted portion. On this bone we have for consideration an *external* or *femoral surface*, which corresponds with the thigh, an *internal* or *pelvic surface*, and a *circumference*.

On the *femoral surface* (*fig.* 47.) we observe the following parts:—On the contracted portion, which unites the upper and the lower half of the os coxæ, is the *cotyloid cavity* (*a*, *figs.* 47, 48.) (from κοτύλη a cup), or *acetabulum*). This is of a hemispherical shape, and is the deepest of all the articular cavities; it looks obliquely downwards, outwards, and a little forwards, and has a considerable depression (*b*, *fig.* 47.) at the bottom on its inner aspect. The margin (*c*) of this cavity is sharp and sinuous, and presents three notches, or rather one notch and two slight depressions, one of which is superior, and the other inferior and somewhat external. The notch (*d*) is situated below and on the inside; it is very deep, and converted into a foramen by a ligament, and gives passage to the vessels which penetrate into the cotyloid cavity. Above and below the acetabulum are two horizontal grooves; the upper one is superficial, and gives attachment to a fibrous expansion, one of the origins of the *rectus femoris*; the lower is deeper, and gives passage to the tendon of the *obturator externus*. Above the cotyloid cavity, the os coxæ presents a broad triangular surface, improperly called *external iliac foss* (*e*). On it we observe, proceeding from behind forwards, 1. a convexity: 2. a concavity occupying about two thirds of the fossa, and on which the principal nutritious foramina are situated: 3. a second convexity: 4. a slight concavity.


Fig. 47.

The external iliac fossa is traversed by two curved lines for muscular insertions; one posterior, called the *superior semicircular line* (*f*); the other anterior, and much more extensive, the *inferior semicircular line* (*g*). All the whole surface behind the former gives attachment to the *gluteus maximus*: the portion comprised between the two lines gives attachment to the gluteus medius.

Below the acetabulum we observe, proceeding from without inwards, 1. the *obturator foramen* (*h*, *figs.* 47 and 48.) improperly so called; it is placed more internally than the acetabulum, and has an oval form in the male (hence its name *foramen ovale*): in the female it is smaller, and triangular. Its longest diameter is vertical, and it slopes a little downwards and outwards. At its upper part is the *obturator groove* (*i*, *fig.* 48.), directed obliquely from behind forwards and inwards. It gives passage to vessels and nerves, and has two *lips*; an *anterior*, which is continuous with the outer half of the circumference of the foramen; and a *posterior*, which is continuous with the internal half; for the two halves of the circumference of the obturator foramen, instead of being united in front, pass in different directions, the internal backwards, and the external forwards, leaving between them an interval which constitutes

the groove. 2. On the inside of the obturator foramen is a square surface (*k*, *figs.* 47 and 48.), broader above than below, oblong in a vertical direction, and rough for the insertion of several muscles of the thigh. This is continuous below with another surface (*l*, *fig.* 47.), broader inferiorly than above, which extends obliquely downwards and outwards, then curves upwards, and terminates below the cotyloid cavity. This surface which bounds the obturator foramen below, is intended for muscular insertions.

The *internal* or *pelvic surface* (*fig.* 48.) of the os coxæ is concave. It is divided into two parts, a superior which looks upwards, and an inferior which looks backwards, by a prominent horizontal ridge (*m n o*, *fig.* 48.), which forms the lower boundary of the internal iliac fossa. Above this ridge, which we shall afterwards see forms the greatest part of the inlet of the pelvis, we find, proceeding from behind forwards, 1. a very prominent and rough *tuberosity* (*r*), intended for several ligamentous attachments: 2. an irregular articular surface, broader above than below, and called the *auricular surface* (*s*) of the os coxæ, from a supposed resemblance to the concha of the ear; it looks downwards and inwards, and articulates with a corresponding surface on the sacrum: 3. more anteriorly, and on a higher plane, a deep and regular excavation, correctly denominated the *internal iliac fossa* (*t*). This fossa which is broad and smooth, is occupied by the iliacus muscle. At its lower part there is a nutritious foramen, which does not correspond with that on the outside of the bone.

Below the horizontal ridge, which divides the internal surface of the os coxæ into two halves, we observe, proceeding from without inwards, and from behind forwards, 1. a smooth quadrilateral surface, broader above than below, slightly concave, and sloping from above downwards, inwards, and forwards; the front of this surface corresponds to the depression at the bottom of the cotyloid cavity: 2. behind this surface, a large notch, which will be noticed when describing the circumference of the bone: 3. in front, the inner opening of the obturator foramen, at the upper part of which is the commencement of the groove already described: 4. inside the foramen a quadrilateral surface, narrower below than above, where it forms a plane, sloping downwards and backwards, which corresponds to the bladder: 5. below the same foramen, a smooth surface.

The *circumference* of the os coxæ is very irregular, and consists of a series of alternate projections and notches. We shall describe four borders in this circumference; a superior, an inferior, an anterior, and a posterior.

The *superior border* or *crest of the ilium* (*u v*, *figs.* 47 and 48.) is curved like the italic letter *S*; it is directed from before backwards, is rough, thick, and convex; we shall describe it as having two lips and an interstice, that we may be able to point out with precision the numerous muscular insertions of which it is the seat. It is not equally thick in its whole extent; the anterior extremity is thick, it is then contracted a little; about two inches behind this extremity it is considerably enlarged; and still more posteriorly there is a second enlargement even greater than the former. The *inferior border* (*w x y′*, *fig.* 47.) which looks inwards is the shortest; it commences at the most sloping part of the os coxæ by a large rough tuberosity, called *tuberosity of the ischium* (*w x*), which gives attachment to almost all the muscles on the back of the thigh; the weight of the body rests upon it in the sitting posture. Proceeding from this tuberosity towards the inner part of the os coxæ (*x y*), the lower border becomes flexuous, irregular, and slightly twisted upon itself; it passes obliquely inwards and upwards, and contributes to form the *pubic arch* (*x y x*, *fig.* 48.). Above this oblique portion the border presents a vertical elliptic surface, which unites with the corresponding surface on the opposite bone, and forms the *symphysis pubis* (*y y′*, *fig.* 47, 48.). The lower border of the os coxæ consists, therefore, of two portions; an oblique, which forms part of the arch, and a vertical, which forms part of the symphysis.

The *anterior border* (*u y′*, *figs.* 47, 48.) commences at the anterior extremity

of the crest of the ilium by an eminence for muscular insertion, which can be always easily felt under the skin; it is the *anterior superior spinous process of the ilium* (*u*). Below, is a notch (*u u'*), which separates this process from another eminence for the insertion of the rectus femoris; it is called *anterior inferior spinous process of the ilium* (*u'*). Below this last process is a notch or angular groove (*u' n*), over which the iliac muscle glides: on this situation the anterior border changes its direction, and from being vertical becomes horizontal. The horizontal portion of the anterior border presents then a smooth concave surface inclined forwards, and shaped like a triangle, with the base outwards. This triangular surface, which is covered by the pectineus muscle, presents, 1. an anterior edge (*, *fig.* 48.), continuous with the anterior lip of the obturator foramen; 2. a posterior sharp edge, called *crest of the pubes* (* *, *figs.* 47 and 48.), a continuation of the horizontal ridge which we have described as forming the lower boundary of the internal iliac fossa; 3. a base presenting the *eminentia ileo-pectinea* (*n n*) which corresponds to the femoral artery, and upon which this vessel should be compressed, care being taken to direct the force obliquely downwards, and backwards, that is, perpendicularly to the surface of the bone; 4. the summit of the triangle has a sharp eminence, which in emaciated subjects forms a marked projection under the skin. This eminence, called *spine of the pubes* (*o*), gives attachment to the rectus abdominis, and must be distinguished from the *angle of the pubes* (*y'*), which is a right angle formed by the meeting of the anterior and inferior borders.

The *posterior border* (*v w*, *fig.* 48.) of the os coxæ commences at the posterior extremity of the crest of the ilium by a sharp eminence, named *posterior* and *superior spinous process of the ilium* (*v*, *figs.* 47, 48.); below is a notch which separates it from another eminence, the *posterior inferior spinous process of the ilium* (*v'*). Below this is a very large notch, the *sciatic notch of the coxa* (*v z*, *fig.* 47.), which contributes to form the great sciatic notch which we shall notice in the general description of the pelvis. This notch is terminated below by a sharp ridge, called the *sciatic spine* (*z*); as this spine sometimes projects inwards, can it, as some have imagined, press upon the fœtal head when it is clearing the lower outlet of the pelvis? Between this spine and the tuberosity of the ischium (*z w*) is a small but well marked groove, over which the tendon of the obturator internus passes.

Internal structure. Like all broad bones, the haunch bone is composed of spongy substance contained between two laminæ of compact tissue; at the bottom of the acetabulum, and in the double concavity of the iliac fossæ, it is thin and semi-transparent; it is thick at the circumference, the crest of the ilium, the upper and back part of the acetabulum, the articular portion of the pubes, and more particularly at the tuberosity of the ischium.

Connections. The os coxæ unites with its fellow of the opposite side, with the sacrum, and with the femur.

Development. The os coxæ is developed from three primitive, and five secondary points of ossification. The three primitive points remain distinct until a very advanced period, and therefore both ancient and modern anatomists have incorrectly described them as separate bones, under the names of *ilium*, *ischium*, and *pubes*. The *ilium* (1, *fig.* 48.) comprehends the upper part of the acetabulum, and the broad curved and triangular surface above it. The *pubes* (2) comprises, 1. the inner part of the acetabulum; 2. the horizontal, prismatic, and triangular column that bounds the obturator foramen above, and which is called the *body of the pubes* (*f*); 3. the vertical descending branch, flattened in front and behind, which bounds the same foramen on the inside, and is called the *descending ramus of the pubes* (*k*, *figs.* 47, 48.).

The *ischium* (3, *fig.* 48.) comprises, 1. the lower part of the acetabulum; 2. a vertical column, very thick, prismatic, and triangular, which forms the tuberosity below, and bounds the obturator foramen on the outside: this is the *body of the ischium* (*l*, *figs.* 47 and 48.); 3. an ascending branch, sloping inwards, flattened in front and behind, which bounds the foramen below and

on the inside, and joins the descending ramus of the pubes; this is the *ascending ramus of the ischium* (*e*, *fig.* 48.). The limits of these three pieces are marked before complete development by three cartilaginous lines, united like the letter Y, at the bottom of the cotyloid cavity (see *fig.* 48.), which is the place where the three primitive osseous points meet, and this fact has contributed, in no small degree, to establish that law of osteogony which we noticed in our general remarks, viz. that when an articular cavity exists upon the surface of a bone which is developed from several points, these points always unite in that cavity.

The following are the complementary points: 1. one at the bottom of the acetabulum, pointed out by M. Serres* and shaped like the letter Y; 2. the *marginal epiphysis*, which occupies and forms the entire length of the crest of the ilium; 3. the epiphysis of the tuberosity of the ischium, which stretches along the ascending ramus; 4. and 5. two epiphyses, which do not seem constant; one occupies the anterior and inferior spinous process of the ilium, the other, still more rare, occupies the angle of the pubes.

The ossification of the os coxæ commences first in the ilium, in the ischium next, and in the pubes last. The osseous germ of the ilium appears on the fiftieth day, that of the ischium at the end of the third month, and that of the pubes at the end of the fifth month. At birth the ossification of the os coxæ is not far advanced; the acetabulum is in a great measure cartilaginous. The ascending ramus of the ischium, the descending ramus of the pubes, and the entire circumference of the ilium, are also cartilaginous. These three pieces are united together from the thirteenth to the fifteenth year. At the same time, the secondary points of ossification appear, and successively unite with the primitive. This union is completed from the tenth to the twentieth year; the epiphysis of the crest of the ilium alone remains separate until the age of twenty-two, twenty-four or even twenty-five years.

The Pelvis in general.

The sacrum, the coccyx, and the haunch bones, having now been described, we are enabled to study the bony cavity which they concur in forming. It is called the *pelvis* (*fig.* 48.), and forms for the lower extremities an osseous girdle, analogous to that which the shoulders form for the upper extremities. The *pelvis* or *basin*, so named because it has been compared to a vase, is a large, irregular, bony cavity, open above and below, which supports the vertebral column behind, and is itself supported by the thigh bones on the sides and in front. In an adult of ordinary stature the pelvis divides the body into two equal parts. In the fœtus the part of the body above the pelvis is much longer than that below; in adults of large stature, on the other hand, the part below is considerably longer than that above.

The pelvis is symmetrical but of a very irregular figure; we may say upon the whole, that it forms a truncated cone, presenting, 1. an upper part or *great pelvis*, oval transversely, much expanded on each side and notched in front; 2. a sort of contracted canal below this upper part, which is called the *little pelvis*. When the pelvis is examined in the skeleton, it has not the horizontal position which it presents when resting on the tuberosities of the ischium and the extremity of the coccyx. It is *inclined* with regard to the axis of the body. The obliquity of the pelvis is not the same throughout, and we have therefore to consider *two axes*, one for the great, and one for the little pelvis. The *axis of the great pelvis* is directed obliquely downwards and backwards, and is re-

* This point of ossification has been regarded as the vestige of a bone peculiar to marsupial animals, and named *marsupial bone*; but this view is incorrect; for, according to Cuvier, this fourth piece is found in marsupials themselves at the bottom of the cotyloid cavity, whereas the marsupial bone is a superadded portion of the skeleton which supports the pouch in these animals.

presented by a line passing from the umbilicus, towards the lower part of the curvature of the sacrum; the *axis of the little pelvis*, on the contrary, is directed downwards and forwards, and is represented by a line passing from the upper part of the curvature of the sacrum, through the centre of the lower opening or outlet of the pelvis. From the direction of these two axes, it follows that the line of direction of the pelvis is a curve with the concavity forwards, and which is pretty correctly represented by the curvature of the anterior surface of the sacrum. This sort of incurvation of the pelvis is an anatomical fact of the greatest consequence, not only on account of the important office which this part of the skeleton performs in the mechanism of standing, but also because without an acquaintance with it, it is impossible to understand the mechanism of natural labour, the curved canal of the pelvis being the path which the infant has to traverse in passing out of the cavity.

The obliquity of the pelvis varies at different ages and in different individuals: it is pretty exactly measured by the prominence of the sacro-vertebral angle.

In the infant the pelvis deviates greatly from the horizontal direction; its upper aperture looks almost directly forwards: in the adult it looks much more upwards; and in the aged it again looks forward, as in the infant, but from a very different cause. In the fœtus the superior aperture is turned forwards, even when the body is upright: at this age the obliquity of the pelvis is inherent in its form; but in the aged, the pelvis looks forward, because the trunk is curved in the same direction, and tends towards a horizontal position as in quadrupeds. Thus, in the fœtus the pelvis has an obliquity which depends on form; in the aged the obliquity depends upon attitude.

The human pelvis is much larger than that of any other animal; and this larger size is connected with the important office it performs in maintaining the erect posture of the trunk.

There is no part of the skeleton, the form and dimensions of which so readily discriminate the sex of the individual; in the male the height predominates; in the female, the breadth. By comparing the distance between the crests and the anterior and the posterior spinous processes of the ilia, and between the obturator foramina, in the two sexes, we find that the transverse dimensions are much greater in the female; the same is observed in the antero-posterior dimensions, which may be easily proved by measuring the distance between the symphysis pubis, and the sacro-vertebral angle, and the distance between each obturator foramen and the sacro-iliac symphysis on the opposite side. We should add, that in the female, 1. the iliac fossæ are larger, and turned more outwards than in the male; hence the prominence of the hips; 2. the crest of the ilium is not so much twisted in form of the italic *S*; 3. the interval between the symphysis pubis and the acetabulum is greater; this is partly the cause of the great prominence of the trochanters, and the separation of the femora, which gives the female a peculiar gait in walking; 4. the superior strait or brim is wider in every direction; 5. the tuberosities of the ischia are more separated, and the symphysis pubis is not so deep; 6. the obturator foramen is triangular; 7. the arch of the pubis is rounded, wider, and more curved, while in the male it is triangular and narrower; 8. the inner edges of the ascending rami of the ischia are prominent, and look less directly downwards than in the male.

Such are the differences of the pelvis as regards sex; we see that for the most part they may be comprehended in the following proposition: —

The female pelvis exceeds the male in its horizontal diameters; the male pelvis exceeds the female in its vertical diameters.

Regions of the Pelvis.

Under this title we shall examine in succession the external and internal surface of the pelvis, the upper circumference or base, and the lower circumference or summit.

The *external surface of the pelvis* must be examined in front, behind, and on the sides.

Anterior region. 1. In the median line we observe the symphysis pubis (*y y*, *fig.* 48). varying from fifteen to eighteen or twenty lines in length, always longer in the male, and resembling a vertical column. It is obliquely directed downwards and backwards, which direction is peculiar to man; in all other animals, as Cuvier has remarked, it is placed horizontally. 2. On each side we find the descending ramus of the pubes (*k*), which is irregularly quadrilateral, and gives attachment to several muscles. 3. Outside the pubic column there is, on each side, the obturator foramen (*h*).

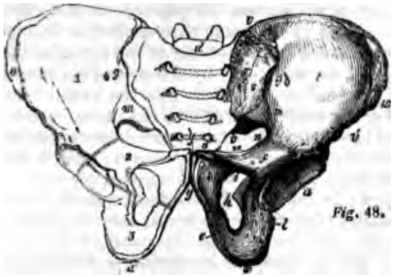


Fig. 48.

Posterior region. On this we observe, 1. the ridge of the sacrum in the median line; 2. and on each side the sacral grooves, which are much deepened above, because the back part of the ilium projects behind the sacrum: we find here, also, two ranges of eminences, corresponding to the articular and transverse processes, and likewise the back of the sacro-iliac articulation.

Each *lateral region* is formed by the external iliac fossa, the acetabulum, and a considerable portion of the body of the ischium below this cavity.

The *internal surface of the pelvis* is divided into two parts; an upper, which is much expanded, and constitutes the *great* or *false pelvis*, and a lower, more contracted, named the *small* or *true pelvis*. These two portions of the same cavity are separated by a circular prominence, formed in a great measure by the horizontal ridge (*m n o*), which we have described as constituting the lower boundary of the internal iliac fossæ. The whole space circumscribed by this line has been named *the brim*, *superior orifice*, or *superior strait of the pelvis*.

The *great pelvis* presents, 1. in front, an extensive notch (*u y′ u*); 2. behind the *sacro-vertebral angle* or *promontory of the sacrum* (below *d*); 3. and on the sides, the internal iliac fossæ (1 and *t*), which form an inclined plane on each side, fitted to direct the weight of the viscera which rest upon them, inwards and forwards.

The *small pelvis* is a cavity the apertures of which are contracted, and therefore named *straits*, and the middle portion is expanded, and called *excavation*.

We shall, therefore, examine separately its superior opening or *upper strait*, its inferior opening or *lower strait*, and its middle portion or *excavation*.

The *superior strait* or *brim* is irregularly circular, and has been compared to an oval, an ellipse, or a curvilinear triangle; but none of these descriptions can give any correct idea of its shape. The circumference, commencing behind, at the articulation between the sacrum and the fifth lumbar vertebra, is formed by the projection of the anterior edge (*g d*) of the base of the sacrum, by the horizontal ridge (*m n*), on the inner surface of the iliac bones, by the pectineal line (*n o*), and terminates in the spine of the pubes. (*o*) The superior strait has *four diameters; an antero-posterior, a transverse*, and *two oblique*. The *antero-posterior* or *sacro-pubic* diameter (*d y′*) is generally four inches in length; the *transverse* (*m m*), which is the longest, is five inches; and the *two oblique* (*n g*), which are measured from the eminentia ilio-pectinea on one side, to the sacro-iliac symphysis on the other, are four inches and a half. These measures are taken from a well-formed female pelvis, and it is chiefly in the female that they are important, on account of their reference to the process of parturition. In the male, all the diameters of the upper strait are smaller.

The *inferior* or *perineal strait*, *inferior* orifice or *outlet* of the small pelvis, presents three deep notches separated by three eminences, so that when the pelvis is placed upon a horizontal plane, it appears to rest as it were upon three feet. Of these notches one is anterior, viz. the *arch of the pubes* ($x\,y\,x$); the others are lateral and somewhat posterior, they are the *ischiatic notches* ($v'\,z$, *fig.* 47.). The *arch of the pubes* is angular in the male, but rounded in the female, forming a true arch which receives the occipital bone of the fœtus in the great majority of labours; it is formed on each side by the ascending ramus of the ischium, the edge of which is somewhat everted, so that the head of the fœtus when passing under the arch glides over a sort of inclined plane, instead of being in contact with the edge of the bone. The *transverse diameter* of the pubic arch near the upper part has been calculated at one *inch*; that of the lower part ($x\,x$, *fig.* 48.) at three *inches*. The two lateral notches are formed behind by the sacrum and the coccyx; in front, by the sciatic notch of the os innominatum; they are therefore called also the *sacro-sciatic notches*. They are very deep, and reach almost to the superior strait of the small pelvis. Of the three *eminences* which separate the notches, the posterior is formed by the coccyx, and the two anterior by the tuberosities of the ischia, which are situated on a lower plane than the first; from this peculiar arrangement, the whole weight of the body, in the sitting posture, rests upon the tuberosities of the ischia, and not at all upon the point of the coccyx. The diameters of the lower aperture of the pelvis are, in reference to parturition, of equal importance with those of the upper, and have been accurately determined. The *antero-posterior* diameter, or *cocci-pubic*, so called because it extends from the symphysis pubis to the point of the coccyx, is four inches, but may be increased to four inches and a half by depression of the coccyx. The *transverse* or *bisciatic* diameter, which stretches between the tuberosities of the ischia, is four inches, which is invariable; and lastly, the *two oblique diameters*, which extend from the middle of the sacro-sciatic ligament on one side to the tuberosity of the ischium on the other, are also four inches each. These dimensions, which are taken from a well-formed female pelvis, are greater than in the male.

Excavation. The excavation or cavity of the true pelvis is formed, 1. Behind, by the sacrum and coccyx, the concavity of which varies in different individuals, but is generally shallower in the female than in the male. The height of these two bones is four inches and a half; the greatest depth of their concavity from ten to twelve lines. 2. In front, by the symphysis and back part of the pubes, forming a plane inclined downwards and backwards; outside the pubes is the inner opening of the obturator foramen. 3. On the sides, the excavation is formed by two smooth planes inclined downwards and inwards; they are about three inches and a half in height, and are bounded behind by the sciatic notch.

It is of great consequence to notice these two inclined planes, because they perform an important part in the mechanism of parturition. The diameters of the excavation being of little value in an anatomical point of view, the student is referred to works on midwifery for an account of them.

The *superior circumference or base of the pelvis* looks forwards, and is formed behind by the sacro-vertebral angle; on each side by the upper border of the ilium, and in front by the anterior border of the same bone. It presents, 1. in front *a vast notch* ($u\,u$, *fig.* 48.), in which we observe *in the median line* the upper part of the symphysis pubis (y'); *on each side* proceeding from within outwards, the spine of the pubes (o), the pectineal surface ($o\,n$), the ilio-pectineal eminence ($n\,n$), and the angular groove for the psoas and iliacus muscles ($n\,u'$). In all this extent the notch is horizontal, but beyond the groove it slants obliquely upwards and outwards, to the anterior superior spinous process of the ilium (u), where it terminates; 2. behind, the great circumference of the pelvis presents the sacro-vertebral angle, and on each side a small notch between the vertebral column and the back of the crest of the ilium; 3. laterally, we ob-

ıe crest of the ilium (*u v*), bent much more outwards in the female than nale.

dimensions of the upper circumference of the pelvis, measured in a rmed female, are the following: 1. between the anterior superior spines ilia from eight to nine inches; 2. from the middle of the crest of one › that of the other, from nine to ten inches.

inferior circumference of the pelvis forms the lower strait which has ready described.

General Development of the Pelvis.

pelvis in the first periods of life participates in the slow development of 'er extremities. Its dimensions, especially in the fœtus and in infancy, small, that it is unable to receive into its cavity many of the organs are afterwards contained in it; this is one of the principal causes of minence of the abdomen of the fœtus. The smaller capacity of the pelvis also from the absence of the iliac fossæ, for these bones are neither . nor excavated, but straight and flat. Nevertheless, the upper or iliac ı is proportionally more developed than the lower or cotyloid, doubtless e this latter part belongs especially to the lower extremities, and also as a protection to the genital organs, both of which are in a rudimentary ı the fœtus. If we examine in detail the differences in size, considered ith reference to the various diameters, we shall find that the transverse y small, because in front the cotyloid cavities are scarcely developed, l the pubic region is contracted; and behind, the iliac bones are more approximated to each other on account of the small size of the sacrum. ntero-posterior diameters appear longer on account of the shortness of nsverse. But the most characteristic feature of the pelvis, in the early s of life, is its much greater inclination than in the adult. In the latter, , a horizontal line drawn from the upper part of the symphysis pubis fall only a few lines below the base of the sacrum, while in the fœtus a : horizontal line would fall nearer the lower than the upper part of the ı. This, as well as the small capacity of the pelvis, is the cause of the 'd position of the bladder, bringing the whole of its anterior surface to pond with the parietes of the abdomen, and consequently rendering it asily accessible to instruments introduced above the pubes.

have already remarked, that the obliquity of the pelvis in the aged, is the same kind as that in the fœtus; and we should add here, that there change in the relative position of the bladder, which, as in the adult, ponds to the back of the os pubis.

The Thigh.

The Femur (*figs.* 49 and 50.).

› femur, or thigh bone, situated between the pelvis and the leg, is the it and largest bone of the skeleton. It is proportionally larger in man n any other animal; this is connected with the office which it performs, porting by itself alone the weight of the body in standing, and trans- g it to the leg. It is obliquely directed downwards and inwards. This ıity is greater in the female than in the male, on account of the greater ce between the acetabula. Too great an obliquity is injurious both in ng and walking, and constitutes a well known deformity.

e femur describes a curve in front and behind, the convexity of which forward, and leaves a sort of excavation behind, which is occupied by ımerous powerful muscles which bend the leg upon the thigh. Indepen- r of this antero-posterior curvature, the femur is slightly twisted upon This curvature of torsion seems to me to be connected with the course femoral artery, which passes round the shaft of the bone from one sur- o the other. Lastly, at its upper part it presents an angular curve which all notice presently.

Like all other long bones the femur is divided into a body and extremities.

Of the body. The body or shaft is prismatic and triangular, with three surfaces and three edges.

The *anterior surface* (*a*, *fig.* 50.) is rounded and has a cylindrical aspect; it is broader below than above.

The *internal surface* (*b*, *fig.* 49.) is flat, it becomes much wider below, and then looks backwards. The femoral artery corresponds to this surface, and may be compressed upon it towards the middle third of the thigh.

The *external surface* (*c*) is much narrower than the internal, and is slightly excavated throughout its extent.

Of the *three edges*, the *internal* and the *external* are rounded, and scarcely distinguishable from the surfaces which they separate. The *posterior edge* (*e d f*), on the contrary, is very rough and prominent, and has therefore been called the *linea aspera:* it is divided into *two lips* and an *interspace*, for the sake of facilitating the description of the numerous muscles to which it gives attachment. It is more rough above than below, and is bifurcated at both ends. Of the two branches of the upper bifurcation, the *external* (*e*), extremely rough, is occasionally surmounted by a considerable eminence, and prolonged to the large process called great trochanter. The *internal branch* is less projecting, and terminates on the inside in a smaller eminence called lesser trochanter. The *outer branch* (*f*) of the lower bifurcation runs towards the outside of the lower extremity of the femur, and terminates in an eminence, below which is a small depression to which the external head of the gastro-cnemius is attached. The *inner branch* (*g*) is nearly effaced at the part where the femoral artery passes over it: below this it appears again, and like the outer branch terminates in a well-marked prominence, to which the adductor magnus is attached, and below it, the inner head of the gastro-cnemius. The triangular interval, included between the two branches of the bifurcation, corresponds to the popliteal artery and vein. The nutritious foramen (*h*) is situated in the linea aspera; it passes from below upwards.

Fig. 49.

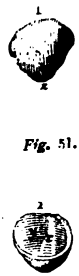


Fig. 51.

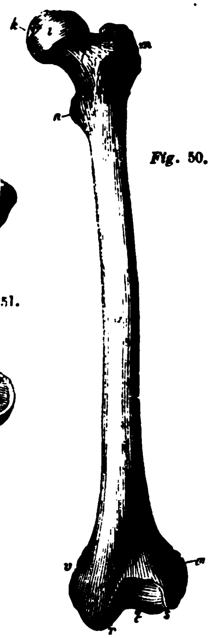


Fig. 50.

The *superior extremity* of the femur forms an obtuse angle with the body, and presents a *head*, a *neck*, and two unequal eminences named *trochanters*, the *great* and *lesser*.

The *head* (*i*, *figs.* 49 and 50.), is the most regularly spheroidal of all the eminences in the skeleton, and forms nearly two thirds of a sphere. In the middle of it we observe a rough depression (*k*) of variable dimensions, which gives attachment to the round ligament. The *neck* (*l*), so called because it supports the head of the bone, is obliquely directed upwards and inwards; it

forms an obtuse angle with the body of the femur (*angle of the femur*), retiring on the inside and projecting on the outside, the degree of which varies in different individuals, at different ages, and in the two sexes. In fact, it is sometimes a very obtuse, and sometimes a right angle: this last is most common in the female, and is one of the causes of the prominence of the great trochanter. The neck is flattened in front and behind, so that its vertical diameter is double the antero-posterior: hence it has more power in resisting force applied from above downwards, than from before backwards, which is a great advantage, since the causes which would produce fractures are almost always applied in the former direction. The anterior surface of the neck is much shorter than the posterior, which is also slightly concave. The upper edge is very short, and presents a great many nutritious foramina; the lower edge is about double the length of the upper. The base of the neck is marked by a number of nutritious foramina; it is bounded in front by some inequalities; behind by the great trochanter above, and the lesser trochanter below; and in the interval between these two, by a projecting ridge which unites them, and which is called the *inter-trochanteric line*.

The *great trochanter* (*m*) is situated at the outer and upper part of the femur. It is on a lower level than the head, and nearly in the same axis as the shaft, which it prolongs upwards. It is of considerable size, and forms a very marked prominence under the skin. It should be carefully studied in its relations; 1. with the crest of the ilium, beyond which it projects on the outside; 2. with the external condyle of the femur; 3. with the external malleolus, because these relations constantly serve as a guide, both in the diagnosis, and the reduction of dislocations of the femur, and of fractures of the neck or shaft of that bone. The great trochanter, which is intended solely for muscular insertions, is of a quadrilateral figure, flattened from without inwards, and presents, 1. an *external surface*, which is convex, and terminates below in a projecting ridge for the vastus externus, and is traversed by an oblique line running downwards and backwards, to which the gluteus medius is attached; 2. an *internal surface*, on which we find a depression called *digital*, or *trochanteric cavity*; 3. a *superior border*, to which the gluteus minimus is attached; 4. an *anterior border*, which is often surmounted by a large tubercle; and 5. a *posterior border*, which gives attachment to the quadratus femoris.

The *lesser trochanter* (*n*) is situated on the inside, behind, and below the base of the neck of the femur; it is a sort of conoid tubercle, and gives attachment to the common tendon of the psoas and iliacus muscles.

The *lower end* of the shaft of the femur is of considerable size: it is broad, transversely flattened in front and behind, and divided into two convex articular processes, called *internal* (*r*) and *external* (*s*) *condyles* of the femur. The external condyle is in the same line as the shaft of the femur. The internal condyle projects on the inside of the axis of the bone, and below the external condyle, so that when both condyles rest on the same horizontal plane, the femur is directed obliquely downwards and inwards. The two condyles are separated behind by a deep notch, called *inter-condyloid notch* (*o*, *fig.* 49.); in front their union forms a sort of pulley, the *femoral trochlea* (*t*, *fig.* 50.), on which the patella rests. That portion of the trochlea which belongs to the external condyle is larger, more prominent, and higher than that which belongs to the internal. Each condyle has three surfaces, 1. the *lower surface*, articular, convex, and rounder behind than in front, is in contact with the tibia and the patella; the lower surface of the internal condyle is more prominent behind than that of the external: 2. the *internal surface* of the external condyle, and the *external surface* of the internal condyle are deeply excavated, and give insertion to the crucial ligaments: 3. the *internal surface* of the internal condyle and the *external surface* of the external condyle present two enlargements, called *tuberosities of the femur*.

The *internal tuberosity* (*v*) is the larger, and has behind a depression situated

downwards. Into this nutritious canal, which is perhaps the largest of any in the long bones, I have seen a nervous twig enter, accompanying the nutritious artery. 4. From the oblique line to the lower end of the tibia, the posterior surface of this bone is smooth, of almost uniform diameter, and divided throughout its length by a more or less marked vertical line.

The *anterior edge* (*c c*) is placed immediately under the skin, beneath which it may be readily felt *: its lower fourth is round and blunt, the upper three fourths are sharp, and hence it has been called the *crest of the tibia.* Its upper part inclines somewhat outwards, its lower part inwards.

The *external edge* (*g k*) gives attachment to the interosseous ligament; it is bifurcated below, and thus forms the two boundaries of an articular cavity which we shall notice in describing the lower end of the tibia. The *internal border* (*f l*), much less sharp than the others, affords insertion to several muscles.

The *upper* or *femoral extremity* (*f g*) of the tibia is at least double the size of the lower, and is larger in a transverse direction than from before backwards; on it we observe two concave articular surfaces, of an oval shape, with their long diameter directed from behind forwards. They have been improperly denominated *condyles;* a more correct name would be *glenoid cavities of the tibia.* These surfaces, which articulate with the condyles of the femur, are not perfectly alike; the internal is longer, narrower, and deeper than the external. They are separated by a pyramidal eminence surmounted by two sharp tubercles. This eminence, which is called the *spine of the tibia* (*e*), is nearer the posterior than the anterior part of the bone. In front and behind this spine are two rough depressions, which give attachment to the crucial ligaments. The glenoid cavities are supported by two considerable enlargements, called *tuberosities of the tibia.*

The *internal tuberosity* (*f*), larger than the external, presents behind a horizontal groove, into which one of the divisions of the tendon of the semi-membranosus is inserted. The *external tuberosity* (*g*) presents at its back part a small almost circular facette, which articulates with a corresponding surface on the fibula. The two tuberosities of the tibia are separated behind by a considerable excavation. In front they are separated by a triangular surface, pierced by vascular foramina, and terminating below in an eminence, called *anterior tuberosity of the tibia* (*h*). This tuberosity, below which the crest of the bone commences, is rough and prominent below, where it gives attachment to the tendon of the extensor muscles of the leg, *ligamentum patellæ;* and smooth above, where it is separated from the same tendon by a synovial bursa. A projecting line runs outwards from this tuberosity, and terminates above in a tubercle, which is very prominent in some individuals, and may be easily felt under the skin. It gives origin to part of the tibialis anticus.

The *lower* or *tarsal extremity* (*l k*) of the tibia is almost square, having, like the upper, its greatest diameter transversely. We observe on it a quadrilateral articular cavity (*i*), transversely oblong, broader on the outside than on the inside, and divided by an antero-posterior ridge, into two unequal parts. It articulates with the astragalus. The circumference of this extremity presents, 1. *in front* a convex surface (*d*), with some inequalities for the insertion of ligaments; it is in contact with the extensor tendons of the toes: 2. *behind*, an almost plane surface, having a shallow depression, which is hardly visible in some subjects, for the tendon of the long flexor of the great toe, and which must not be confounded with an oblique groove, situated on the inner side, and which will be described with the internal malleolus: 3. on the *outside* a triangular cavity (*k*), broad and smooth below, narrow and rough in its two upper thirds, which articulates with the fibula: 4. on the *inside* a thick qua-

* The superficial situation of the anterior edge of the tibia renders it a good guide to surgeons in the diagnosis and coaptation of fractures of the leg. It also greatly exposes the bone to injury from external violence. It is not uncommon to find it broken, or as it were notched, by gun-shot.

drilateral process, flattened on the outside and the inside, and called the *internal malleolus* (*l*). This eminence, which bends inwards, forms a marked prominence at the lower and inner part of the tibia. When the posterior surface of the tibia is laid upon a horizontal plane, the two tuberosities of the upper end of the bone rest upon that plane, while the internal malleolus advances considerably forwards; it is therefore upon a plane anterior to that of internal tuberosity of the tibia; this depends upon the torsion of the lower part of the bone. The *internal surface* (*l*) of the malleolus is convex, and is placed immediately under the skin; its *external surface* forms part of the inferior articular cavity of the tibia. Its *anterior edge* is rough, and gives attachment to ligamentous fibres; its *posterior edge*, which is thicker than the anterior, presents a groove running obliquely downwards and inwards, and sometimes double, along which the tendons of the tibialis posticus and flexor longus digitorum pass. The *base* of the malleolus is united to the shaft of the bone. The *summit*, which is truncated and slightly notched, gives attachment to the internal lateral ligament of the ankle joint.

Connections. The tibia articulates with the femur, the astragalus, and the fibula; it articulates also with the patella, but indirectly by means of the ligamentum patellæ.

Internal structure. The shaft consists of compact tissue, and has a large medullary canal. The two extremities are spongy, and are pierced by a great number of vascular foramina.

Development. The tibia is developed from three points; one for the body, and two for the extremities. Sometimes there are four. Béclard once saw the internal malleolus developed from a separate point. The ossific point of the shaft is the first to make its appearance; it commences between the thirty-fifth and fortieth day, almost at the same time as that of the body of the femur; sometimes it is even earlier, as in one case observed by myself. The bony germ of the upper extremity makes its appearance generally towards the end of the first year after birth. I have never seen it before birth. The ossification of the lower extremity commences during the second year. The internal malleolus is formed by a prolongation of this extremity. The union of all the parts of the bone is not finished until the period of complete development of the body, that is, from the eighteenth to the twenty-fifth year; it always commences with the lower extremity, which is the last to become bony. It is of importance to remark, that the superior epiphysis of the tibia does not form the whole of the upper end of the bone, but only a sort of horizontal plate which supports the articular cavities; and the same is true of almost all articular extremities. It should also be observed, that the anterior tuberosity of the tibia is formed by a vertical prolongation of the plate which forms the superior epiphysis. It would appear, that in some subjects this anterior tuberosity has a distinct centre of development.

The Fibula (*fig.* 53.).

The *fibula* or *perone* (from περόνη) is so named because, according to Sabatier, it has been compared to a sort of clasp or brace, in use among the ancients.

In order to understand the description of this bone, it is necessary to place it exactly in the position which it occupies in the skeleton.* It is situated on the outside of the tibia below, on the outside and to the back of the same bone above. It is as long as the tibia, but is extremely slender; it is indeed the

* We have hitherto deemed it unnecessary to indicate the position in which each bone should be studied, because a glance at an articulated skeleton would suffice to enable the student at once to place the bones aright. The fibula, however, forms an exception, on account of its remarkable torsion. In order, then, to study this bone correctly, it is necessary to place the flattened end (*u v*) downwards, taking care that the articular surface on that part be turned inwards, and that the thin edge (*u*) of the eminence which forms this lower end should look forwards.

most slender of all the long bones, and may be at once recognised by this character. Its direction is vertical, with a slight inclination outwards at its lower part. It is the most twisted of all the long bones, and is a remarkable exemplification of that law of osteology, viz. that the *torsion of bones is always connected with changes of direction of tendons*, or *vessels*. It is divided into a body and two extremities.

The *body* has the form of a triangular prism. In order rightly to comprehend its shape, it is necessary to be aware that the muscles which are placed on its external surface above, turn round to the posterior aspect below, from which it is easy to understand how the four upper fifths of the external surface look outwards, and the lower fifth backwards.

The *external surface* (*n*) is marked by a deep groove which runs along it, and gives attachment to the *peroneus longus* and *peroneus brevis*. The lower part, which is turned backwards, is smooth. The *internal surface* is divided into two unequal parts by a longitudinal ridge, to which the interosseous ligament is attached. The portion of the surface in front of the ridge is narrower than the other, being in some subjects not more than two lines in breadth; it gives attachment to the muscles on the fore part of the leg; the portion behind the ridge is larger, and gives attachment to the tibialis posticus. This surface becomes anterior at its lower part (*o*).

The *posterior surface* of the fibula is narrow above, and expanded below, where it looks inwards, and terminates by a rough part, to which ligaments that unite it to the tibia are attached. The whole of this surface gives attachment to muscles. We observe on it the principal nutritious canal, which passes obliquely downwards. This canal is sometimes placed on the internal surface of the bone.

The *three edges* participate in the deviations of the surfaces. Thus the *outer edge* (*r*) becomes posterior below; the *anterior edge* (*s*) becomes external, and is bifurcated; the *internal edge* becomes anterior, and after being thus changed forms the continuation of the ridge for the interosseous ligament, which we noticed upon the inner surface.

All the edges give attachment to muscles, and are remarkable for their prominence.

The *superior extremity* or *head* (*t*) of the fibula presents an *articular facette* (near *t*), slightly concave, which unites with a corresponding surface on the tibia: on the outside are some irregular impressions for the insertion of the biceps muscle, and the external lateral ligament of the knee. At the back part of this head we observe the *styloid process of the fibula* (below *t*) for the tendon of the biceps.

The *lower extremity* or *external malleolus* (*u v*) passes much below the inferior articular surface of the tibia; it is longer and thicker than the internal malleolus. It is flattened on the outside and the inside, and presents, 1. an *external surface* (*u v*), convex, and sub-cutaneous: 2. an *internal surface*, which articulates with the astragalus, by means of a facette, which completes on the outside the sort of mortise formed by the union of the lower ends of the tibia and fibula; below and behind this surface is a deep rough excavation which gives attachment to a ligament: 3. an *anterior edge* (*u*) for the insertion of a ligament: 4. a *posterior edge* (*v*), thicker, marked by a superficial groove for the passage of the tendons of the peronei muscles: 5. a *summit*, which gives attachment to one of the external lateral ligaments of the ankle joint.

Connections. The fibula forms the outer part of the leg, and articulates with the tibia and the astragalus.

Internal structure. The shaft is compact, and has a very small medullary canal, and the extremities are spongy.

Development. The fibula is developed from three points, one for the body, and one for each extremity. The osseous point of the body appears a little after that of the shaft of the tibia, from the fortieth to the fiftieth day. At birth, the two extremities are still cartilaginous. An osseous point appears in

the lower end during the second year: that of the upper end about the fifth. The extremities are united to the shaft of the bone when the development is completed, viz. from twenty to twenty-five years; the lower end is the first to become joined.

The Foot (*figs*. 54, 55, and 56.).

The *foot* is the part of the lower extremity which is analogous to the hand in the upper. They are both but varieties of the same type of organisation, with certain differences which have reference to their respective uses. In the foot, for example, which is intended to support the body, the conditions necessary for solidity are principally manifest, while the hand is chiefly remarkable for the mobility of its parts.

The foot is composed of twenty-six bones, which, by their union, form three distinct parts, viz. 1. the *tarsus* (*c i f*, *fig*. 54.), a bony mass consisting of seven pieces closely articulated; 2. the *metatarsus*, composed of five separate columns (*m m'*, *figs*. 54 and 55.); and 3. the *toes*, formed each of three columns (*n o r*), excepting the first, or most internal, which has only two (*n' r'*).

Fig. 54.

Fig. 55.

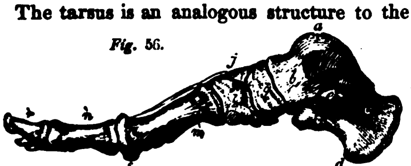
The size of the foot varies in different individuals. It exceeds the hand in thickness and length, but is not so broad. Its direction is horizontal from before backwards, and it forms a right angle with the leg, differing much in this respect from the hand, which is in the same line as the forearm. It is flattened from above downwards, is hollow below (*fig*. 56.), narrow behind, where it is of considerable height, and thinner and broader in front, at which part also it is digitated. It presents, 1. a *superior* or *dorsal surface*, which is convex, *dorsum pedis* (*fig*. 54.); 2. an *inferior* or *plantar surface*, which is concave transversely, and likewise in the antero-posterior direction, *sole of the foot* (*fig*. 55.); 3. an *internal* or *tibial edge* (*fig*. 56.), which is very thick, and corresponds to the great toe: 4. an *external* or *fibular edge*, which corresponds to the little toe; 5. a *posterior extremity* or *heel*; 6. an *anterior* or *digital extremity*.

We shall describe in succession the tarsus, the metatarsus, and the toes.

The Tarsus (*figs*. 54, 55, and 56.).

The tarsus is an analogous structure to the carpus, but differs from it in forming the posterior half of the foot, while the carpus only constitutes about a sixth of the hand. Its antero-posterior diameter surpasses by more than double its transverse, precisely the opposite of what obtains in the carpus.

Fig. 56.



It resembles a vaulted arch, the convexity of which (*c a j*, *fig*. 56.) looks upwards, and which is excavated below (*d i*) both transversely and from before backwards. The weight of the leg falls upon the summit of this arch. This form of the foot is not designed merely for securing the ad-

vantages derived from the mechanism of arches, but is especially intended to afford a protecting excavation for the organs which could not with impunity be compressed in standing and progression. The posterior and free extremity of the tarsus is narrow, and progressively enlarges forwards.

The tarsus is composed of seven bones, disposed in two rows. The *first* or *tibial row* is formed by two bones only, the *os calcis* (*c*), and the *astragalus* (*a*); the *second* or *metatarsal row* consists of five bones, viz. the *scaphoid* (*g*), the *cuboid* (*f*), and the *three cuneiform bones* (*i j l*). The bones of the first row, instead of being placed in the same transverse line like those of the first row of the carpus, rest one upon the other. The astragalus is the only bone of the tarsus which enters into the formation of the ankle joint.

First or Tibial Row of the Tarsus.

The Astragalus (*a*).

The *astragalus* is placed below the tibia, above the os calcis, on the inside of the malleolar extremity of the fibula, and behind the scaphoid; it is irregularly cuboid in its figure, is the second largest bone of the tarsus, and has six surfaces. 1. The *superior* or *tibial surface* (*a*, *fig.* 54.) is articular, and shaped like a trochlea or pulley, which fits exactly to the lower surface of the tibia. In front and behind the trochlea, are inequalities for the attachment of ligaments. 2. The *inferior* or *calcaneal surface* (*a*, *fig.* 55.) presents two facettes, separated by a very deep *furrow* running obliquely backwards and inwards, and broadest in front, which gives insertion to a ligament. The facette behind the groove is the larger; it is concave and oblong in the same direction as the groove. The facette in front is flat, and often divided into two smaller surfaces. Both articulate with the os calcis. 3. The *internal lateral surface* (*fig.* 56.) is articular for a considerable portion of its upper part, and corresponds to the internal malleolus; below, there is a rough depression, which gives attachment to the internal lateral ligament of the ankle joint. 4. The *external lateral surface* is triangular, like the corresponding surface of the external malleolus, with which it articulates. It should be remarked that both the lateral articular surfaces of the astragalus are continuous with the trochlea, or upper surface, without interruption. 5. The *anterior* or *scaphoid surface* is convex, and has been called the *head of the astragalus*; it is articular, and continuous below, with the anterior facette of the lower surface of the bone already described. This head is supported by a contracted portion, or *neck* (*b*, *fig.* 54 and 56.), to which ligaments are attached. 6. The *posterior surface* is very small; it consists simply of a groove slanting downwards and inwards, along which the tendon of the flexor longus pollicis pedis glides.

The Os Calcis (*c*).

The *os calcis* or *calcaneum*, situated below the astragalus, and at the lower and back part of the foot, is the largest bone of the tarsus. Its form is irregularly cuboid, with the greatest diameter from before backwards; it is flattened transversely. Its size and its length have reference to the double office which it serves, of transmitting the weight of the body to the ground, and of acting as a lever for the extensor muscles of the foot. I should remark that its large posterior extremity forms the *heel* (*d*, *figs.* 55, 56.), the horizontal direction of which, in man, is one of the most advantageous arrangements for the vertical position of the body.

The os calcis has six surfaces. 1. The *superior surface* (*fig.* 54.) presents in front, two, or often three, articular facettes, which correspond with those on the lower surface of the astragalus. The posterior facette is the larger, convex, and separated from the anterior by a groove, which is shallower than the cor-

responding one of the astragalus, but follows the same direction backwards and inwards. The whole of the non-articular portion of this surface projects behind the astragalus; it is flattened on the sides, and slightly concave from before backwards. Its length varies in different individuals, and is the cause of the varieties in the projection of the heel. 2. The *lower* or *plantar surface* (*fig.* 55.) is rather an edge than a true surface; it is directed obliquely upwards and forwards. We observe here, at the back part, *two tuberosities*, the internal of which is much larger than the external; both serve as places of insertion for muscles, but their principal use is to support the weight of the body behind, and they *essentially* constitute the heel (*d, fig.* 56.) in the human subject. 3. The *external surface* is superficial, which accounts for the frequency of injuries of this bone on its outside, and explains also the possibility of reaching it with surgical instruments. It is convex, and narrow in front, where it presents two superficial grooves separated by a tubercle (*s, figs.* 54 and 55.). These grooves afford a passage to the tendons of the peroneus longus and brevis. On the anterior and superior part of this surface we find also another tubercle, which is a guide to the surgeon in the partial amputation of the foot, recommended by Chopart. 4. The *internal surface* (*fig.* 56.) is deeply grooved for the passage of several tendons, and also for the nerves and vessels which are distributed to the sole of the foot. It presents in front and above a projecting eminence, like a blunt hook, in a shallow groove, below which the tendon of the flexor longus pollicis pedis glides. This eminence has been called the *small process of the os calcis* (*e, fig.* 56.), also *sustentaculum tali*, because the anterior and internal articular surface, which supports the astragalus, is on its upper part. 5. The *anterior* or *cuboid surface* is the smallest. It is concave from above downwards, and articulates with the cuboid. It is surmounted on the inside by a short projection, directed horizontally forwards*, above which the third articular surface for the astragalus is situated when it exists. The whole portion of the os calcis which supports the anterior or cuboid surface bears the name of *great process of the os calcis* (*t, figs.* 54 and 55.). 6. The *posterior surface* is shaped like a triangle, with the base downwards; its lower part is rough and irregular, and gives attachment to the tendo Achillis, the upper part, over which the same tendon glides, being smooth and polished like ivory

Second Row of the Tarsus.

The bones of the second row are five in number; on the outside it is formed by the cuboid alone, but on the inside it is subdivided into two secondary rows; a posterior, formed by the scaphoid, and an anterior, composed of the three cuneiform bones. This subdivision of the inner portion of the tarsus, by multiplying the articulations, has the effect of diminishing the violence of shocks, or of pressure upon the foot, especially on the inner side.

The Cuboid Bone (*f, figs.* 54 and 55.).

The *cuboid* which ranks as the third bone of the tarsus in point of size, is situated at the outside of the foot, and appears like a continuation of the great process of the os calcis. It is more regularly cuboid than any of the other tarsal bones, and has six surfaces. 1. The *upper* or *dorsal surface* (*fig.* 54.) is covered by the extensor brevis digitorum pedis, and looks somewhat outwards. 2. The *lower* or *plantar surface* (*fig.* 55.) presents on its fore part a deep groove (*f*), running obliquely inwards and forwards, for the tendon of the peroneus longus. Behind this groove, the posterior lip of which is very prominent, are impressions for the ligament which connects the cuboid and the os

* This small prolongation, which might be called *small anterior process of the os calcis*, in contra-distinction to the one on the internal surface already mentioned, merits notice in the performance of Chopart's operation

calcis. 3. The *posterior* or *calcaneal surface* is sinuous, directed obliquely inwards and backwards, and adapted to the os calcis in such a way that there is a mutual reception of the surfaces of the two bones. At the inside of this surface, we observe a process which is directed inwards and backwards, and strengthens the union with the os calcis. It occasionally becomes an obstacle to the disarticulation of the foot after Chopart's method. 4. The *anterior* or *metatarsal surface* looks obliquely inwards and forwards; it articulates with the fourth and fifth metatarsal bones. 5. The *internal surface* articulates with the third cuneiform bone, and frequently also with the scaphoid. It presents, besides, some impressions for the insertion of ligaments. 6. The *external surface* is rather an edge; its extent from before backwards scarcely equals half the length of the internal surface. We observe on it the commencement of the groove for the tendon of the peroneus longus.

The Scaphoid (*g*, *figs.* 54, 55, and 56.).

The *scaphoid* or *navicular bone*, so named from its supposed resemblance to a boat, is situated on the inner side of the tarsus; it is flattened from before backwards, and is thicker above than below, irregularly elliptical, with the long diameter placed transversely. It has two surfaces, and a circumference. 1. The *posterior surface* is concave, and receives, though incompletely, the head of the astragalus. 2. The *anterior surface* presents three articular facettes, which correspond to the three cuneiform bones. 3. The *circumference* is convex *above*, inclined inwards, and rough for ligamentous insertions. It is much smaller *below*, where also it gives attachment to ligaments. On the *inside* it presents at its lower part a large process, *process of the scaphoid* (at *g*), which may be easily felt under the skin, and serves as a guide in performing Chopart's amputation. This process gives attachment to the tendon of the tibialis posticus. On the *outside* the circumference is irregular, gives attachment to some ligamentous fibres, and often presents a small surface which articulates with the cuboid: this surface is continuous with the facettes for the three cuneiform bones.

The three Cuneiform Bones.

These bones, so named from their shape, are three in number: they are called *first*, *second*, and *third*, counting from the inside of the foot. They are also distinguished by their size, into the *great*, *middle-sized*, and *small*.*

The first Cuneiform Bone (*i*, *figs.* 54, 55, and 56.).

The *first* or *internal cuneiform* bone is the largest. It is placed on the inside of the others, in front of the scaphoid, and behind the first metatarsal bone. It is shaped like a wedge with the base below, which is precisely contrary to what obtains with the other two. We observe on it, 1. an *internal surface* (*fig.* 56.), which is subcutaneous, and forms part of the inner edge of the foot: 2. an *external surface*, which presents an angular articular facette for union with the second cuneiform bone behind and the second metatarsal bone before; the non-articular portion of the external surface of the first cuneiform bone is rough, and gives attachment to ligaments: 3. a *posterior surface* which is concave, and articulates with the most internal and largest facette on the anterior surface of the scaphoid: 4. an *anterior* or *metatarsal surface*, which is plane, or rather slightly convex, of a semilunar form, the convexity being to the inside, and the greatest diameter vertical; it is broad below, and narrow above, and articulates with the first metatarsal bone: 5. an *inferior surface* (*fig.* 55.), which forms the base of the wedge; it is rough, with a tubercle be-

* Also, by position, into *internal*, *middle*, and *external*.

hind for the attachment of the tibialis anticus: 6. an *upper part* (*fig.* 54.), which forms the point of the wedge; it is an angular border running forwards and upwards, and thicker in front than behind, where it contributes to form the convexity of the foot.

The second or middle Cuneiform Bone (*j, fig.* 54, 55, and 56.).

The *second cuneiform bone* is the smallest of the three: it is placed between the two others, and corresponds to the scaphoid behind, and the second metatarsal bone in front. The wedge which it represents has the base turned upwards; its length from behind forwards is very inconsiderable. It presents, 1. an *internal surface*, which is triangular, and articulates with the first cuneiform bone: 2. an *external surface*, which articulates with the third or external cuneiform bone: 3. a *posterior*, or *scaphoid surface* which is concave, and articulates with the middle facette on the anterior surface of the scaphoid: 4. an *anterior* or *metatarsal surface*, which is triangular, and narrower than the posterior; it articulates with the second metatarsal bone: 5. a *superior surface* (*fig.* 54.), or *base* of the wedge, which is irregularly square, and rough for the attachment of ligamentous fibres: 6. an *apex* (*fig.* 55.), which is very thin, and gives attachment to some ligaments.

The third or external Cuneiform Bone (*l, figs.* 54, and 55.).

This bone, which is the third as regards position, and the second in point of size, has, like the preceding, the form of a wedge with the base turned upwards. Its *internal surface* articulates behind with a corresponding surface on the preceding bone, and in front with the second metatarsal. This last portion completes the kind of recess or mortise into which the head of the second metatarsal bone is received; its inner side being formed by the first cuneiform bone, and the bottom by the second. The *external surface* articulates with the cuboid: the *posterior surface* is continuous with the two lateral ones, and articulates with the most external of the three facettes on the scaphoid: the *anterior surface* is triangular, and articulates with the end of the third metatarsal bone: the *base* (*fig.* 54.) is rough, and forms part of the convexity of the foot: the *apex* (*fig.* 55.) is more obtuse than the same part of the second cuneiform bone, and passes considerably below it.

Structure of the bones of the tarsus. The bones of the tarsus present the structure common to all short bones, viz. a mass of spongy tissue surrounded by a layer of compact substance. I have remarked, that in some cases of white swelling of the ankle joint, the os calcis contained in its interior a cavity analogous to the medullary canal of long bones. This cavity, however, must be looked upon as altogether abnormal.

Development of the tarsal bones. With the exception of the os calcis, which has two osseous germs, all the bones of the tarsus are developed from single points. The os calcis first becomes ossified. A bony nodule appears in the centre of its cartilage, about the middle of the sixth month of fœtal life, according to most osteogonists; in the fifth, or even the fourth month, according to others. It is placed much nearer the anterior than the posterior extremity of the future bone. Another osseous germ is formed in the posterior extremity of the os calcis, from the eighth to the tenth year, and is much thicker at its lower than at its upper part. The astragalus is developed from one point, which appears from the fifth to the sixth month of inra-uterine life. According to Béclard, the cuboid is not ossified until some months after birth; I have observed the process to be already commenced in a fœtus at the full term. Meckel says that it begins after the eighth month of fœtal life. Blumenbach, on the contrary, makes the time of its ossification a year and half, or two years after birth; and Albinus, who has been followed in this respect by the generality of anatomists, affirms that in the fœtus at the full period, all the

bones of the tarsus, excepting the os calcis and the astragalus, still remain cartilaginous.

The cuneiform bones are developed in the following order:— The first is ossified towards the end of the first year: the second and the third appear almost simultaneously about the fourth year: the os calcis being the only bone of the tarsus which has more than one point of ossification, is also the only bone in which we have to examine the order of union. The two points which form it are not united until the fifteenth year.

The Metatarsus (*m m'*, *figs.* 54 55, and 56.).

The metatarsus forms the second portion of the foot. Like the metacarpus, its analogous part in the hand, it consists of five long bones, parallel to each other, forming a sort of quadrilateral grating, the intervals of which, called *interosseous spaces*, are increased by the disproportion between the ends and the shafts of the bones. The metatarsus presents, 1. an *inferior* or *plantar surface* (*fig.* 55.), with a marked transverse concavity; 2. a *superior* or *dorsal surface*, (*fig.* 54.), which is convex, and answers to the back of the foot; 3. an *internal* or *tibial edge* (*m'*, *fig.* 56.) which is very thick, and corresponds to the great toe; 4. an *external* or *fibular edge*, which is thin, and corresponds to the little toe; 5. a *posterior* or *tarsal extremity*, which presents a waved articular line; 6. an *anterior* or *digital extremity*, presenting five heads flattened on the sides, which assist in forming five separate articulations. The bones of the metatarsus have certain characters which distinguish them from all others, besides some peculiar marks by which they may be known from each other, and from the metacarpal bones, with which they have many analogies.

General Characters of the Metatarsal Bones.

The metatarsal bones belong to the class of long bones, both in shape and structure. Each consists of a *body* and *two extremities*. The *body* is prismatic and triangular, and slightly curved, with the concavity below. Two of its surfaces are lateral, and correspond to the interosseous spaces; the third, so narrow that it resembles an edge, is on the dorsum of the foot. Two of the edges are lateral; the third is below on the plantar aspect of the foot.

The *posterior* or *tarsal extremity* is much expanded, and presents five surfaces, *two of which are non-articular*, and *three articular*. Of the two non-articular surface sone is superior, and the other inferior; both give attachment to ligaments. Of the three articular surfaces, one is posterior, that is, on the extremity of the bone; in general it is triangular, and articulates with a corresponding surface on one of the tarsal bones. The other two are lateral, partly articular, and partly non-articular. The articular surfaces are small, and often consist of more than one; they join the contiguous metatarsal bones. The tarsal extremity is wedge-shaped; the upper or dorsal surface being very broad, represents the base of the wedge; the lower surface being narrow, forms the point.

The *anterior* or *digital extremity* presents a head or *condyle* flattened on the sides, and oblong from above downwards; the articular surface extends much further on the lower aspect, or in the direction of flexion, than on the upper, or the direction of extension. On the inside and outside of the condyle there is a depression, and a projection behind it for the lateral ligament of the joint.

Characters of the different Metatarsal Bones.

The *first* or *metatarsal bone* of the great toe (*m'*, *figs.* 54, 55, 56.) is remarkable for its great size. It is the only one which, in this respect, resembles the tarsus; *its body* is shaped like a triangular prism; its *digital extremity* is marked on the plantar aspect by a double furrow for two sesamoid bones (*s*, *fig.* 56.). (Vide *Articulation of the Foot.*) Its tarsal extremity presents a semilunar concave surface, with its greatest diameter vertical, which articulates with the

the internal cuneiform bone. There is no articular surface on the circumference of the first metatarsal bone. In this point it resembles the first metacarpal bone, and by this and its great size it is distinguished from all the others.

The *fifth metatarsal bone* (*m*, *fig.* 54, 55.) is the shortest after the first; it has only one lateral articular face on its tarsal extremity. On the opposite side of this extremity, viz. on the outside, we observe a large process, *process of the fifth metatarsal bone*, shaped like a triangular pyramid, and directed obliquely backwards and outwards, into which the peroneus brevis is inserted. This process may be easily felt under the skin, and serves as a guide in the partial amputation of the foot at the tarso-metatarsal articulation. Another characteristic of the fifth metatarsal bone is the great obliquity outwards and backwards of the articular face on its posterior extremity.

The second, third, and fourth metatarsal bones are distinguished from each other by the following characters.

The *second* is the longest, and also the largest after the first; it articulates with the three cuneiform bones by its posterior extremity, which is dovetailed with them. The *third* and the *fourth metatarsal bones* are of almost equal length; their apparent difference in an articulated foot depends chiefly on the fact, that the articulation of the fourth with the cuboid is on a plane posterior to that of the third with the external cuneiform bone. Lastly, they may be known from each other by the presence of two surfaces, on the inside of the posterior extremity of the fourth metatarsal; one being for the external cuneiform bone, and the other for the third metatarsal bone.

Development. The metatarsal bones are developed from two points; one for the body, and one for the anterior or digital extremity. The first metatarsal bone is the only exception to this rule, for its epiphysary point is situated at the posterior extremity.* The osseous point of the body appears first during the third month, according to the majority of authors, but about the forty-fifth day, according to the observations of Blumenbach and Béclard. It is completely developed in the fœtus at the full period. The epiphysary point makes its appearance during the second year. The union of these parts does not take place until the eighteenth or nineteenth year, and is not simultaneous in all the bones of the metatarsus. The epiphysis of the first metatarsal bone is the first to unite with the body. An interval of a year sometimes intervenes between the union of this epiphysis and those of the other four metatarsal bones.

The Toes (*n o r*, *n r*, *figs.* 54, 55.).

The resemblance between the phalanges of the fingers and those of the toes is so complete, that we cannot do better than refer to the description already given of the former, for details respecting the latter. At the same time it should be remarked, that the phalanges of the toes appear, as it were, atrophied, or stinted in growth, when compared with those of the fingers, excepting the great toe, which in all its parts preserves the large dimensions of the inner side of the foot.

The *first* or *metatarsal phalanx* (*n* to *n'*) resembles closely the metacarpal phalanx of the fingers. The *middle phalanx* (*o*) is remarkably small and short; it would almost appear to consist of the extremities alone, the body being absent. At first sight it might be taken for a pisiform bone, or rather for one of the pieces of the coccyx; but the presence of anterior and posterior articular faces is sufficient to mark the distinction.

The *ungual phalanges* (*r r'*) of the toes resemble in form, but are much smaller than the corresponding parts of the fingers. This remark, however,

* This exception corresponds entirely with that observed in the hand, and renders the analogy between the metatarsal bone of the great toe and the metacarpal of the thumb extremely close; for the same reason, both of these bones resemble the first phalanges of the fingers. I may add that, in some subjects, it has appeared to me that there was a very thin epiphysary point at the digital extremity of this bone, which soon united to the body.

only applies to the last four, for the ungual phalanx of the great toe is in size at least double that of the thumb. I cannot conclude this description without remarking that the articular surface of the posterior extremity of the metatarsal phalanges, as well as of the anterior extremity of the metatarsal bones, is prolonged further upwards than the corresponding surfaces on the metacarpal bones and phalanges of the fingers; this arrangement allows a greater extension of the toes, and is an important element in the mechanism of progression.

Development. The first, second, and third phalanges are developed from two points of ossification; one for the body, and one for the metatarsal extremity. The epiphysary points of the second and third phalanges are so small, that their existence has been doubted by many anatomists. The osseous points of the bodies of the first phalanges are much later in appearing than those of the metatarsal bones, not being visible in general until from the second to the fourth month; the first phalanx of the great toe is an exception, its ossification commencing from the fiftieth to the sixtieth day. The epiphysary point of the first phalanges does not appear until the fourth year. The bodies of the second phalanges are ossified almost at the same time as those of the first; the epiphysary point of their posterior extremity is not visible until from the sixth to the seventh year. The bodies of the third phalanges are ossified before those of the second and the first; an osseous point appears in them about the forty-fifth day, excepting in the little toe, where it is much later. The ungual phalanx of the great toe is remarkable as being ossified before all the other phalanges of the toes. It is developed from a point which does not occupy the centre, but the summit of the phalanx. The epiphysary point of the posterior extremity appears about the fifth year in the great toe, and about the sixth year in the other four. The epiphysary points of the phalanges are not united to the bodies until the age of seventeen or eighteen years.

General Development of the Inferior Extremity.

The most characteristic feature of the lower extremity in the fœtus is the comparative lateness of its development, which is most remarkable at the early periods. We have already stated the periods at which each point of ossification appears in the different bones, and the times at which they are united, and it now only remains for us to point out some peculiarities of development which have not been included in the description of the bones.

From the observations of Bichat, it is generally admitted that the neck of the femur in the fœtus and the newly-born infant is proportionally shorter than in the adult, and forms almost a right angle with the shaft of the bone; that the body of the femur is almost straight; and that its extremities are proportionally much larger than they become subsequently. As we before observed, with regard to the upper extremities, all these assertions are at variance with the results of our observations. The same reflections apply equally to the bones of the leg, the torsion of which we believe to exist to the same degree in the fœtus and in the new-born infant, as in the adult.

After birth, the development of the lower limbs proceeds more rapidly than that of the upper, and the final proportions are not attained until the age of puberty. In the aged, the phalanges of the toes are often anchylosed; but this union, like the dislocations of the toes, and some deformities of the tarsus and metatarsus, are the results of pressure upon the foot occasioned by tight shoes, and the more or less complete immobility in which the parts are maintained.*

* On this subject the reader may consult a very curious memoir, by Camper, on the inconveniences arising from tight shoes, to which he attributes, 1. the shortening of the second toe; 2. the partial luxation of some of the tarsal bones. To this we may add the luxation, outwards, of the first phalanx of the great toe; and the luxation, inwards, of the first phalanx of the second, and sometimes of the third toe.

Comparison of the Superior and Inferior Extremities.

We have hitherto omitted the applications of that species of comparative anatomy by which different organs of the same animal are compared with one another. Those analogies which exist between the various parts that compose the trunk, could not, with propriety, be included in a work on descriptive anatomy. But we do not deem it proper to apply the same rule to the parallel between the upper and lower extremities; for that is founded on such numerous and striking points of analogy, and has become so much a subject of instruction, that we should consider it a serious omission did we here neglect giving a brief notice of it.

The upper and the lower extremities are evidently constructed after the same type, but present certain modifications corresponding to the difference of their functions. I should remark in this place, that some of these analogies are very manifest and satisfactory, and greatly facilitate the remembrance of important anatomical details; while others are far-fetched and wholly destitute of useful application: these will be passed over with a simple notice. We shall now compare in succession the shoulder and the haunch, the humerus and the femur, the fore-arm and the leg, the hand and the foot.

Comparison of the Shoulder and the Pelvis.

Before the time of Vicq-d'Azyr, anatomists were in the habit of considering the clavicle and the scapula among the bones of the upper extremity, but regarded the os innominatum or haunch as belonging to the trunk; and yet the most simple reflection is sufficient to establish the analogy between the shoulder and the haunch. In order the more readily to appreciate the points of resemblance and difference between these parts, it is advisable to follow the method adopted by Vicq-d'Azyr, of studying the shoulder reversed; or, what is the same thing, to compare the aspect of the shoulder which corresponds to the head, with that of the pelvis, which answers to the coccyx; remembering at the same time, that for a long period after birth the haunch-bone is formed of three distinct pieces — the ilium, the ischium, and the pubes.

1. The shoulders form an osseous girdle, intended to form a point of support for the upper extremities, in the same manner as the haunch does for the lower extremities. The girdle formed by the shoulders is interrupted in front in the situation of the sternum, and behind, opposite the vertebral column; hence there are two shoulders, while the haunch-bones constitute one united whole. The shoulder, therefore, and consequently the arm of one side, are completely independent of those of the other, but the two lower extremities have a solid bond of union.

2. The second point of difference relates to the comparative dimensions of the pelvis and the shoulder. The great size of the pelvis, the thickness of its edges, the depth of its notches, and the prominence of its eminences, contrast strongly with the slender construction of the shoulder, and the thin edges of the scapula, and are in harmony with the uses of the lower extremities.

3. The broad portion of the scapula is analogous to the iliac portion of the os innominatum; the internal iliac fossa is analogous to the subscapular fossa.

4. The supra and infra-spinous fossæ correspond to the external iliac fossa; but the ilium has no part analogous to the spine of the scapula.

5. The axillary border of the scapula answers to the anterior edge of the os innominatum. The spinal border is analogous to the crest of the ilium. The superior border of the scapula corresponds to the posterior border of the os innominatum; and the coracoid notch on this border, with the coracoid ligament which converts it into a foramen, are analogous to the sciatic notch, and the sacro-sciatic ligaments.

6. The glenoid cavity is evidently analogous to the acetabulum; according

to Vicq-d'Azyr, the coracoid and the acromion processes are represented by the tuberosity of the ischium and the pubes, with this remarkable difference only, that the two processes of the shoulder are separated from each other by the large acromio-coracoid notch, while in the pelvis the ischium and the pubes are united, and, instead of including a notch, form the circumference of a foramen, the obturator. This analogy is not universally admitted; for the ischium being intended to sustain the weight of the body when sitting, bears no resemblance in this respect to the shoulder. One of the most striking analogies between the shoulder and the pelvis is that of the clavicle and the horizontal portion of the pubes; with this difference, that the clavicle is articulated with the scapula, while the pubes is united by bone to the ilium. Without forcing an analogy, we may trace a similitude between the symphysis pubis, and the union of the clavicles by means of the interclavicular ligament.

Comparison of the Arm-bone and the Thigh.

In order to make the parallel exact, we must remember the relative situation of these two bones, and compare the right femur with the left humerus; and the side of flexion, that is, the posterior aspect of the first, with the side of flexion or the anterior aspect of the second. This being determined, we must place the linea aspera of the femur in front, and the humerus in its natural position. The humerus is much smaller than the femur, being about a third shorter, and only half the weight and bulk. The humerus is placed vertically, and almost parallel to the axis of the trunk; in this it contrasts with the marked obliquity of the thigh-bones, which touch each other at their lower ends. The humeri are separated from each other by a greater distance than the femora; this difference depends on the conformation of the human thorax, which is flattened in front and behind, while in quadrupeds it is flattened on the sides, and permits the approximation of the humeri, which serve as pillars of support to the fore part of the trunk.

The humerus is not curved like the femur, but, on the other hand, it is much more twisted, and presents an oblique groove, which does not exist in the femur. We shall compare in succession the shafts and the extremities of these bones.

1. *Comparison of the shafts.* The posterior surface of the humerus exactly corresponds to the anterior surface of the femur, being, like it, smooth and rounded. The external surface resembles the external plane of the femur, with some differences; the impression for the gluteus maximus is evidently analogous to the deltoid impression. The internal surface is in contact with the brachial artery, as is the internal surface of the femur with the femoral artery. The anterior edge is a sort of linea aspera, analogous to that of the femur, and, like it, terminating by a bifurcation at its upper part.

2. *Comparison of the lower ends of the bones.* Although the differences between these parts are very marked, we can yet detect, in the one bone, traces of all the more important points of structure observed in the other. Thus the internal and external tuberosities of the humerus evidently resemble those of the femur, and they are both intended for the insertion of muscles and ligaments. The trochlea of the humerus resembles that of the femur, with this difference, that in the femur the two borders of the pulley diverge from each other behind, while in the humerus they are parallel throughout. In front and behind the femoral trochlea, we find depressions, which are manifestly analogous to the coronoid and olecranal fossæ of the humeral trochlea. Lastly, without admitting any fundamental difference, we may explain the existence of the small head of the humerus, for which there is no representative in the femur, by a reference to the fact, that both bones of the fore-arm unite with the humerus, while only one bone of the leg articulates with the femur.

3. *Comparison of the upper ends.* As in the femur, we find in the humerus a segment of a spheroid, or a head, supported by a neck, of which, however

there is only a trace; and two tuberosities, which are analogous to the trochanters, and, like them, give attachment to the rotator muscles of the limb. In the humerus, however, the two processes are much more closely approximated, being only separated by the bicipital groove. Lastly, the great tuberosity of the humerus causes the prominence of the shoulder, in the same manner as the great trochanter causes the prominence of the hip.

Comparison of the Leg and Fore-arm.

The fore-arm is that portion of the upper extremity, which is represented by the leg in the lower. Each is composed of two bones; but while the leg is essentially constituted by the tibia, which alone enters into the formation of the knee-joint, and the greater part of the ankle-joint, both the radius and the ulna contribute, almost in an equal degree, to that of the fore-arm; and although the ulna forms the greater part of the elbow-joint, the radius, by a sort of compensation, is the chief bone of the wrist-joint.

Although the general analogy between the fore-arm and leg is sufficiently striking, it is not so easy to trace the corresponding parts in detail. Anatomists are much at variance on this subject, particularly as to which bone of the fore-arm corresponds to the tibia.

Vicq-d'Azyr, from a consideration of the elbow and the knee-joints, came to the conclusion, that the ulna is analogous to the tibia, and the radius to the fibula. M. de Blainville, on the contrary, reflecting on the relations between the leg and foot, and the fore-arm and hand, and considering that the tibia is placed on the same line with the great toe, and the radius with the thumb, and also that in the fore-arm the radius constitutes the chief part of the wrist-joint, and that in the leg the tibia is most concerned in the ankle-joint, is of opinion that the tibia and the radius are analogous parts.

We shall adopt what is true in either opinion, and reject what appears to us too unconditionally stated or incorrect; and therefore, considering, 1. that neither of the bones of the leg resembles, by itself, one of the bones of the fore-arm, 2. that each bone of the leg has some characters, both of the ulna and of the radius, 3. that the natural position of the fore-arm being that of pronation, and that the leg being in a state of constant pronation, it is incorrect to compare the fore-arm when supinated with the leg when in the opposite position, 4. that comparative anatomy has shown, in ruminating animals, the upper extremity of the ulna to be blended with the radius, and a slender process on the external aspect of the fore-arm resembling the fibula, we are inclined to believe, that the upper end of the tibia is represented by the upper half of the ulna, and the lower half of the tibia by the lower half of the radius; while the fibula is represented by the upper part of the radius and the lower part of the ulna. If we enter into details, we shall see how plausible this comparison is in reality.

Comparison of the Upper Half of the Ulna and the Upper Half of the Tibia.

The horizontal portion of the great sigmoid cavity of the ulna is represented by the upper end of the tibia, and the crest which separates the two surfaces of the cavity is analogous to the spine of the tibia. The patella and the olecranon are constructed after the same type; the mobility of the first, and the fixture of the last, are not essential differences. The body of the ulna is prismatic and triangular, like that of the tibia; its internal surface is superficial and almost subcutaneous, like the anterior surface of the tibia; its posterior edge (crest of the ulna) is prominent, and represents the crest of the tibia; it is equally superficial, and serves as a guide in the diagnosis and coaptation of fractures. As in the tibia, the crest of the ulna is continuous with a triangular tuberosity, which may be called the posterior tuberosity of the ulna, and is analogous to the anterior tuberosity of the tibia.

Comparison of the Lower Part of the Radius and the Lower Part of the Tibia.

The quadrangular lower end of the radius corresponds to the equally quadrangular lower extremity of the tibia. The inferior articular surface of both is divided into two parts, by an antero-posterior ridge. The ulnar side of the lower end of the radius is hollowed into an articular cavity, in the same way as the fibular side of the lower end of the tibia. The styloid process of the radius answers to the internal malleolus of the tibia. Both extremities exhibit furrows for the passage of tendons.

Comparison of the Hand and Foot.

The back of the foot corresponds with the back of the hand, the sole with the palm, the tibial edge of the one with the radial edge of the other; the fibular and the ulnar borders are analogous; the tarsal extremity of the foot corresponds with the carpal extremity of the hand, and each has a digital extremity. But amidst these features of resemblance, which are sufficient to establish the old adage, *pes altera manus*, we find also great differences. Thus the foot exceeds the hand both in size and weight, being longer and thicker, though it is narrower: this excess of volume does not affect the toes, which are incomparably smaller than the fingers; nor the metatarsus, but is confined to the tarsus, of which the carpus seems little more than a vestige. A second characteristic difference is the absence of the power of opposition in the great toe. As far as regards function, indeed, it may be truly said, that the want of this power constitutes a foot, and the possession of it a hand. A third difference results from the mode of articulation of the leg with the foot, for the leg does not articulate with the posterior extremity of the tarsus, but with its upper surface, so that a part of the tarsus projects behind the joint, and the axis of the foot forms a right angle with that of the leg. These remarks will suffice to show the general differences between the hand and the foot.

Comparison of the Bones of the Carpus and Tarsus.

While the carpus scarcely forms the eighth part of the hand, the tarsus constitutes half the foot. Its antero-posterior diameter, which is five or six inches, is three times greater than the transverse diameter, precisely contrary to what is the case in the hand. The tarsus resembles a vault, concave below, both in the antero-posterior and transverse directions; and receives the leg upon its summit. The carpus is nothing more than a groove for tendons. It is manifest that the carpus is only the rudiment of the tarsus, which is not surprising, if we consider that the former is truly the fundamental part of the foot, and the basis of support to the whole body. We shall examine in detail the analogies and the differences of these two constituent parts of the foot and the hand. They differ in the following respects: 1. There are eight bones in the carpus — there are only seven in the tarsus; 2. Each of the two rows of the carpus is composed of four bones — the first row of the tarsus consists of two bones, and the second of five; 3. The bones of the first row of the tarsus are placed one above the other, not arranged side by side as in the first row of the carpus; 4. One tarsal bone only enters into the formation of the ankle-joint, while three of the carpal bones are concerned in the wrist-joint; lastly, the second row of the tarsus is subdivided into two secondary rows on the inside, a posterior, formed by the scaphoid, and an anterior, formed by the three cuneiform bones.

We shall now compare the bones of these two regions, and for the want of their resemblance in shape, we shall have recourse to that of their mode of connection, — a method which is perhaps more constant and important than that which is founded upon a character so variable as figure.

Comparison of the Metatarsal Row of the Tarsus with the Metacarpal Row of the Carpus.

The metatarsal and the metacarpal rows are evidently more analogous to each other than the first rows of each region, and have therefore been chosen for the purpose of establishing the parallel.

1. The cuboid is manifestly analogous to the os unciforme; their relative positions are the same; their forms are in a great measure similar; and while the cuboid is attached to the two last metatarsal bones, the os unciforme articulates with the two last metacarpal. This analogy being admitted, we shall find in the three cuneiform bones the representatives of the three other bones of the second row of the carpus, viz. the trapezium, the trapezoid, and the os magnum.

2. We must admit here that the analogies now become much less evident. Nevertheless, the third cuneiform bone, which from being in contact with the cuboid should represent the os magnum, which is contiguous to the os unciforme, does so far agree, that it articulates with the third metatarsal bone, as the os magnum does with the third metacarpal; and, what is sufficiently remarkable, the third cuneiform has a slight connection with the second metatarsal, as the os magnum has with the second metacarpal. Although, therefore, we do not find in the third cuneiform bone any thing approaching to the size of the os magnum, or resembling the remarkable head of that bone, we should not on that account hastily conclude that they have no analogy. We shall explain afterwards how this fact should be interpreted: we only wish it to be admitted in this place, that the base or metacarpal portion of the os magnum is represented by the third cuneiform bone.

3. The second cuneiform bone, which corresponds to the trapezoid, supports the second metatarsal, as the trapezoid supports the second metacarpal.

4. The first cuneiform bone, which supports the first metatarsal, corresponds to the trapezium, which supports the first bone of the metacarpus. All these analogies, it must be confessed, are very imperfect, and founded rather upon the connections than the forms of the different bones. In fact, what resemblance is there between the three large cuneiform bones all cut into facette-like wedges and all so like each other in shape, and the bones of the carpus to which we have compared them? Above all, what comparison can be established between the third cuneiform, which exactly resembles a wedge, and the os magnum, which has a rounded head? There is nothing in the metatarsal range of the tarsus which represents the rounded head which belongs to the metacarpal row of the carpus; but the following considerations, which did not escape the notice of Vicq-d'Azyr, will serve to solve the difficulty.

1. It is an observation which applies with sufficient generality to the whole skeleton, that when two bones move upon each other, one being provided with a head, and the other with a cavity, the head moves upon the cavity, not the cavity on the head. Thus, the femur moves upon the os innominatum; the humerus upon the scapula. 2. The hand, in the performance of its functions, almost always moves upon the fore-arm. In the movements of the hand, the metacarpal row of the carpus moves upon the first row, and therefore the metacarpal row presents the head. On the contrary, in the movements of the bones of the tarsus during progression, the bones of the first row always move upon those of the second or metatarsal row; and consequently, instead of finding a rounded head in the second row, we meet with it in the first.

Proceeding thus by the method of exclusion, it now only remains for us to establish the analogy between the bones of the first row of the carpus on the one hand, and the scaphoid, the os calcis, and astragalus on the other. The analogies here are very equivocal, and are not agreed upon among anatomists.

Comparison of the First Row of the Tarsus with the First Row of the Carpus.

As there are only three bones in the posterior row of the tarsus, which correspond to the antibrachial or superior row of the carpus, it might be supposed, *à priori*, that one of these would correspond to two of the bones of the first row of the carpus. A very slight examination of the tarsus and the carpus in a quadruped will show at once, that the pisiform bone is represented by that part of the os calcis which projects behind the astragalus. The os calcis is the only bone of the tarsus which is developed from two points; and this establishes a strong presumption in favour of the opinion, that it represents two bones. If we admit the analogy of the back part of the os calcis with the pisiform bone, the anterior portion of this bone would represent the cuneiform or pyramidal bone of the carpus; and as this last articulates with the os unciforme, so the anterior portion of the os calcis unites with its representative, the cuboid. The os calcis then may be considered as representing the cuneiform and the pisiform bones blended together and much augmented in size.

It remains then to establish the analogy between the scaphoid and semilunar bones of the hand, and the astragalus and scaphoid of the foot.

The scaphoid of the hand resembles the scaphoid of the foot, both in form and connections. The similarity of shape has led to the identity of name: and with regard to connections, we find that the scaphoid of the foot is attached to the three cuneiform bones, and that of the hand to the trapezium, the trapezoid, and the os magnum, which represent the three cuneiform bones; and lastly we observe, that the scaphoid bone of the foot is placed on the same side as the great toe, and that the scaphoid bone of the hand is placed on the same side as the thumb. There is, however, one remarkable difference between them, viz. that the scaphoid bone of the hand articulates with the forearm, while that of the foot has no connection with the leg.

We have now only to discover in the tarsus the representative of the semilunar bone. All the rest of the bones being now excluded, we can only conclude with Vieq-d'Azyr, that the astragalus is its counterpart, with the mere addition of a rounded head.

Comparison of the Metacarpus and the Metatarsus.

Five small long bones, arranged parallel to each other, form both the metacarpus and the metatarsus. In both there are four interosseous spaces: these are larger in the hand than in the foot, because there is a greater disproportion between the bulk of the extremities and shafts of the metacarpal than of the metatarsal bones; the metacarpus, from being shorter, appears broader than the metatarsus. The most distinguishing character of the metacarpus is the fact, that the metacarpal bone of the thumb is the shortest of the whole, and is situated on a plane anterior to the others; and that its direction is oblique, all which circumstances bear reference to the movement of opposition, which is peculiar to the hand. The characteristic mark of the metatarsus is the size of the first metatarsal bone, which greatly exceeds that of all the others. The great size of the tarsus is continued in this bone and the great toe, on account of the important part they perform in the mechanism of standing. There is so great a resemblance between the other metacarpal and metatarsal bones, that some attention is necessary in order to distinguish between them. 1. The metatarsal bones gradually diminish in size from their tarsal to their digital extremities; the metacarpal bones, on the contrary, are most expanded at their digital ends. The metacarpal are shorter and thicker, the metatarsal longer and more slender. The shaft of the metacarpal bones is pretty regularly prismatic and triangular; that of the metatarsal, on the contrary, is compressed or flattened on the sides. 2. There are no well-marked differences between the carpal extremities of the metacarpal bones, and the tarsal extremities

of the metatarsal; but the latter are larger than the former, which agrees with the greater dimensions of the tarsus. 3. The tarsal extremities are more regularly cuneiform than the corresponding ends of the metacarpal bones.

The most characteristic differences, however, of these two series of bones are found in the digital extremities, which are incomparably larger in the metacarpus than in the metatarsus, the fingers being the chief part of the hand, while the tarsus is the principal portion of the foot. We should also remark, that the convex articular surfaces of the digital ends of the metatarsal bones are prolonged further on the dorsal aspect, than the corresponding surfaces of the metacarpal bones.

Comparison of the Phalanges of the Fingers and Toes.

The fingers, being the essential organs of prehension and the fundamental part of the hand, greatly exceed the toes both in length and thickness, and the latter may be looked upon as representing in rudiment the former, being precisely analogous in structure.

The phalanges of the toes may therefore be regarded as phalanges of the fingers in a state of atrophy; but the great toe forms a remarkable exception to this rule, for its phalanges are much larger in proportion to the other toes, than the phalanges of the thumb are to the other fingers. This magnitude of the great toe corresponds to the size of its metatarsal bone, and accords with its destination, as constituting the principal support for the weight of the body in front. The first phalanx of the toes exactly resembles the first phalanx of the fingers in all things but volume. The middle phalanx of the toes can scarcely be recognised from its diminutive size: it may be said to want the shaft altogether, the extremities being in contact. As we have already remarked it might at first sight be confounded with a pisiform, or a sesamoid bone, or still more readily with a piece of the coccyx.

Comparison of the Upper and Lower Extremities with regard to Development.

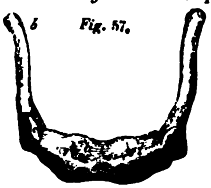
The development of the lower extremities is proportionally less rapid than that of the upper. The clavicle and the scapula are ossified before the os innominatum. The ossification of the skeleton commences in the clavicle; in this bone, the osseous nodule is visible from the twenty-fifth to the thirtieth day; it appears in the scapula about the fortieth day. The osseous point of the ilium is visible about the forty-fifth day, that of the ischium in the third month, and that of the pubes in the fifth month. The scapula is completely ossified at the age of twenty years, the marginal process of the crest of the ilium is scarcely united until the twenty-fifth year. The bony centres of the shafts of the femur and humerus are almost simultaneous in their appearance. The germ of the lower end of the femur always exists at birth; that of the lower end of the humerus does not appear until the end of the first year; but this latter unites with the bone at eighteen years, while the former is still separate at twenty years. The tibia is ossified a little before the bones of the fore-arm, the fibula a little after them. The ossification of the leg and the fore-arm is completed almost about the same time. The ossification of the bones of the tarsus precedes that of the carpus by a considerable period. Thus, at frome four and a half to five months of fœtal life, abony point is visible in the os calcis, and some days after in the astragalus; the os magnum and os cuneiforme (which, however, are not the representatives of the preceding), do not show ossific points until a year after birth. The pisiform bone is not ossified until the twelfth year; while the latest of the tarsal bones, the scaphoid, is converted into bone at the fifth year. Nevertheless, the epiphysary point of the os calcis (which we have shown to be analogous to the pisiform bone) does not become visible until the tenth year; this fact strengthens the analogy between the pisiform bone and the epiphysary lamina of the os calcis.

The metatarsal bones are developed in exactly the same manner as the metacarpal, only at a somewhat later period. The union of the epiphyses takes place a little earlier in the metatarsus than in the metacarpus. The toes are ossified at a later period than the fingers; especially the ungual and the second phalanges, which are much later than those of the fingers.

It is, no doubt, impossible to state the precise reason for these differences; but it is sufficient to find a positive relation between the rate of development of these parts, and the offices they are intended to fulfil.

*The Os Hyoides, or the Hyoid Apparatus** (*fig* 57.)

The *os hyoides* has a parabolic form, resembling the upsilon of the Greeks, whence its name. It is the only bone which is detached from the rest of the skeleton; it is connected only by ligaments and muscles, and is situated between the base of the tongue and the larynx. It is larger in the male than in the female. It is placed almost horizontally, the concavity of its curve looking backwards, and the convexity forwards.



This bone is divided into five parts; viz. *a body* or middle part (*a*), and *four cornua*, two large (*b*), and two small (*c*). This multiplicity of parts, which is much greater in some animals, especially fishes, justifies the name of hyoid apparatus which we have adopted.†

The *body of the os hyoides* (*a*) is quadrilateral, elongated, and curved, with the cavity behind. Its *anterior surface* looks upwards, and presents a crucial projection, the vestige of a process which in many animals is prolonged into the substance of the tongue. This projection gives attachment to several muscles, the insertions of which are marked by transverse lines, interrupted by tubercles. The *posterior surface*, more or less excavated in different individuals, is sometimes connected with a yellow cellular tissue, which separates it from the epiglottis, and is sometimes covered by a synovial membrane. Its excavation, which is never very great in man, is the vestige of the enormous cavity which exists in the hyoid of the Howler monkey. The *lower edge* gives attachment to the thyro-hyoid muscle only. The *upper edge* gives insertion to a yellow membrane, a sort of ligament which stretches into the tongue; and also to the yellow thyro-hyoid ligament, which has been incorrectly stated to be inserted into the lower edge of the bone. The *extremities* of the body of the os hyoides are covered by cartilage for articulation with the great cornua.

The *great cornua* or *rami* (*b*) are much longer than the body, and flattened above and below, while the body is compressed from before backwards. They are expanded at the place where they articulate with the body, pass backwards, and, after being contracted and flattened, terminate in a rounded tubercle, which is sometimes surmounted by an epiphysis.

The *little cornua* (*c*) are called also *styloid cornua*, because they are connected with the styloid process by means of a ligament. They are two pisiform nodules at the point of junction of the great cornua with the body of the hyoid (*ossa pisiformia lingualia*, of Soemmering). They surmount the upper edge of the bone, and are directed upwards and outwards; their length is very variable. In the lower animals, the prolongations which correspond to these little cornua, are much longer than the great cornua in man. They articulate by their lower end with the body and the great cornua. Their upper part

* I have introduced the description of the os hyoides into this place, because, although chiefly belonging to the tongue, it gives attachment to several muscles, and therefore should be previously known to the student.

† Vide M. Geoffroy Saint-Hilaire, on the anterior bones of the chest. (*Philos. Anat.* vol. i. p. 139.)

gives attachment to a ligament, which unites it with the styloid process. This ligament, which is sometimes ossified in man, is always a bony connection in the lower animals.*

Internal structure. The hyoid bone is composed chiefly of compact tissue; but there is a small quantity of spongy tissue in the thick parts of the body and the great cornua.

Development. The os hyoides is developed from five points; one for the body, two for the great cornua, and two for the little cornua. Some anatomists admit two points for the body, and make the whole number six.

The ossification of the great cornua precedes that of the body, which becomes bony soon after birth; the little cornua are not ossified until some months after. All the pieces are at first separated by considerable portions of cartilage, afterwards by a very thin layer, which sometimes remains during life, and gives the different parts of the bone a great degree of mobility.

* In the lower animals the styloid process is detached from the cranium, and forms one of the hyoid chain of bones, which is composed, 1. of the five pieces of the os hyoides; 2. of the bones which supply the place of the styloid ligaments: 3. of the styloid processes, or rather bones: nine pieces in all.

THE ARTICULATIONS, OR ARTHROLOGY.

General observations.—Articular cartilages.—Ligaments.—Synovial membranes. —Classification of the joints.—Diarthroses.—Synarthroses.—Amphiarthroses, or symphyses.

THE bones are united together by the *joints* or *articulations*. The study of these parts is the object of *syndesmology*, or more properly of *arthrology* (ἄρθρον, a joint). In examining each joint it is necessary to consider, 1. the contiguous surfaces of the bones, or the *articular surfaces*; 2. the uniting medium, or the *ligaments*; 3. the means or conditions which facilitate the motion of the parts, the *synovial membranes*; and 4. the movements of which the joint is capable.*

It is impossible to insist too much upon the importance of a careful study of the articulations. There is no part of anatomy a thorough knowledge of which is more indispensable both to the physiologist and the surgeon; without it the former cannot form a correct idea of the animal mechanism, nor can the latter appreciate the nature of those numerous injuries and diseases of which the articulations are the seat.

Before describing the forms and the motions of the different joints, it is necessary to give a general idea of the articular cartilages, the synovial membranes, the ligaments, &c.; in short, of all the means which contribute to secure the solidity and mobility of the articulations

The Articular Cartilages.

It has been observed †, that when two osseous surfaces in immediate contact rub upon each other, they are gradually absorbed in such a manner as to render the movements between them difficult and painful. In order to avoid these injurious effects in the joints, the contiguous surfaces of the bones are covered by a layer of cartilage (the *incrusting* or *articular cartilage*), a substance which unites in itself the qualities of solidity, pliability, and elasticity in a high degree, yielding when compressed, and returning to its former state when the pressure is removed. These articular cartilages exist in all the moveable joints. The extent of surface which they cover is generally proportioned to the extent of motion in the joints. Their thickness is generally greatest, when the bones which they cover are most moveable, and most subjected to pressure. An articular cartilage is not of uniform thickness throughout. Thus, on convex surfaces the cartilaginous layer is thicker in the centre than at the circumference; and, on the other hand, the cartilages of articular cavities are thickest at the circumference. The most perfect co-aptation results from this arrangement. It should also be remarked, that the most violent shocks are applied to the centre of the heads of the bones, and to the circumference of the cavities.

The articular cartilages present, 1. a *free surface*, perfectly smooth and polished, which is in the interior of the articulation; 2. an *adherent surface*, which is so closely attached to the tissue of the bone, that it is impossible to separate it excepting in cases of disease. In some cases of white swelling, I have been able to remove the articular cartilages with great facility, and in these it appeared that the adherent surface of the cartilage was very irregular, and that the fibres of the bone were implanted in it by innumerable small prolongations.

There is another kind of cartilage existing in certain joints in the form of

* Three of these, viz. the configuration of the articular surfaces, the ligaments, and the movements of the joint, are essentially related to each other; so that we may deduce, *à priori*, the means of union, and the movements of any joint, from the shape of the articular surfaces, and *vice versâ*.

† Absorption of the cartilages is a frequent disease of the joints, and obliges the individuals affected by it to maintain constant rest.

ıe simply in contact.

ırticulations of continuous surfaces are provided with cartilages very t from the above, and which should be looked upon as non-ossified of the original cartilage of ossification. The progress of ossification encroaches upon them, while the regular articular cartilages are never in this way. It will be seen afterwards that the articular cartilages ganic, like the enamel of the teeth, and the horny tissues, which are way by attrition, and are not susceptible of any lesions excepting such from mechanical injury or chemical action.*

The Ligaments. †

ligaments constitute a very important division of the fibrous tissue, s met with in all parts where great resistance and great flexibility are l; and in no part of the body are these requisites more necessary than oints. They consist of bundles of flexible and inextensible fibres of r white lustre, sometimes parallel, and sometimes interlaced. Some- hey are placed between the osseous surfaces, and are then named *ous;* sometimes, on the contrary, they occupy the circumference of the , and are then called *peripheral* or *capsular.* The peripheral ligaments two surfaces, a *deep surface* lined by the synovial membrane, which is ly united to it, and a *superficial,* which is in contact with the muscles, , nerves, vessels, and cellular tissue; and also *two extremities* which are l to the bones, at a greater or less distance from the cartilage. The a of these parts is so intimate, that it is easier to break either the liga- the bone than to separate them at the precise place of their union.

igaments may be classed under two very distinct heads: 1. the fasci- or those which exist in bundles; and 2. the membranous or capsular. aments, properly so called, belong to the first class; the fibrous cap- long to the second. We may admit a third form, which consists of scat- bres, too far separated to form fasciculated ligaments, and too few in to constitute articular capsules. We should include also, in the class ılar ligaments, two very remarkable modifications of the fibrous tissue.

The Synovial Membranes, or Capsules.

In every part of the body where fibres move, they are surrounded by cellular tissue, which secretes a lubricating fluid to facilitate their motions; and, where surfaces move upon each other, they are covered by a membrane which exudes a fluid, varying in its nature, according as the motions are confined to simple gliding, or are accompanied by a certain amount of friction. In the first case the membranes secrete a watery or serous fluid, and are consequently denominated *serous membranes*: in the second, the liquid is of an unctuous nature, resembling white of egg; it is called *synovia* (σὺν, with, and ᾠὸν, an egg), and the membrane *synovial membrane*. All the moveable articulations are provided with a synovial membrane or capsule, by means of which the parts are constantly lubricated with a viscid unctuous fluid, that favours the exact adaptation of the articular surfaces, obviates the effects of friction, and maintains them in contact. This is the cause of the noise or cracking which results from the sudden separation of the articular surfaces.

The synovial capsules, which have been well described by Monro, are thin transparent membranes, forming shut sacs, which cover the heads of the bones without admitting them into the interior of the cavity. In fact, it is their *external surface* which adheres more or less intimately to the ligaments and other parts which surround the joint, while their *internal surfaces* are in contact with each other, and are constantly lubricated by the synovia. It is a question among anatomists, whether the synovial membrane covers also the articular cartilages. It can only be traced by the knife as far as the circumference of these cartilages, and if it exists on them, which analogy would lead us to believe, it is so completely modified as not to be recognisable. Without admitting or denying the fact, for the sake of facility in description we shall assume the continuity of this membrane over the cartilages. In many joints the synovial membrane is raised from the surface of the parts by a subjacent cushion of fat, which projects into the joint, and which Clopton Havers imagined to be a gland for secreting the synovia. I believe that this, which may be called synovial fatty tissue, is only intended to fill up the spaces which would otherwise be formed in many articulations during the performance of certain movements. The synovial fringes, described by the same author as the excretory ducts of these glands, are nothing more than folds of the membrane.

Classification of the Joints.

The multiplicity of the articulations, and the analogies and differences which they present, have induced anatomists to arrange them in a determinate number of groups, having well-marked characteristics. The shape of the articulating surfaces in each joint, the arrangement of the uniting media, and the variety and extent of motions, being necessarily correlative, either of these three circumstances may be taken as the basis of classification. Most of the older anatomists, attending specially to the means of union, divided the articulations into four classes: 1. *synchondroses* (σὺν, with, and χόνδρος, a cartilage), when the bones are united by means of cartilage; 2. *syneuroses* (σὺν, with, and νεῦρον, a nerve, the synonyme of ligament among the ancients), when the connection is established by ligaments; 3. *syssarcoses* (σὺν, with, and σὰρξ, flesh or muscle), those joints in which muscles form the uniting medium; 4. *meningoses* (μήνιγξ, a membrane), when membranes serve as ligaments, as in the bones of the cranium in infants. This classification can only be regarded as a rough sketch.

Bichat, fixing his attention entirely upon the movements, has divided the moveable joints according to the variety of motions of which they are capable. There are four kinds of motion: 1. *gliding*; 2. the *movement of opposition*, when a bone is alternately moved in opposite directions, as in flexion

and extension; 3. the movement of *circumduction*. when the bone which is in motion describes a cone, the apex of which is at the joint, and the base is traced by the opposite end of the bone; 4. the *movement of rotation*, in which a bone rolls on its axis, without changing its place.

Proceeding on this classification of the movements, Bichat arranged the articulations in two great classes, the moveable and the immoveable. The latter he divided according to the nature of the articular surfaces, the former according to the number of motions, in the following order: — *1st class:* those joints which are capable of every kind of motion, viz. gliding, opposition, rotation, and circumduction; *2d class*, those joints which are capable of all the motions, excepting rotation; *3d class*, those joints which are only capable of opposition, or alternate motions in the same plane; *4th class*, those joints which admit only of rotation: *5th class*, those joints which are only capable of a gliding motion. We should observe that gliding occurs in all the preceding forms of articulation.

This classification, which is almost exclusively founded upon a consideration of the movements, is eminently physiological. For this reason we shall reject it, because in the study of anatomy the consideration of functions is of secondary importance, compared to that of structure. The motions of a joint are also evidently the consequence of the shape of its articular surfaces.

The classification now generally adopted is that of Galen, with some modifications. Taking the presence or absence of mobility as the primary ground of division, the articulations are divided into the *moveable* or *diarthroses*, and the *immoveable* or *synarthroses*. To these two great divisions Winslow has added a third, under the name of *mixed articulations*, or *amphiarthroses* (ἄμφω, both), because they participate of the characters of both, viz. mobility, and continuity of surfaces.*

For the determination of the secondary divisions regard has been had both to the shape of the articular surfaces, and to the movements of which the joint is capable. Thus, the *diarthroses* have been subdivided into 1. *enarthroses*, when the head of one bone is received into the cavity of another; 2. *arthrodia*, when the articular surfaces are plane, or nearly so; 3. *ginglymus*, when the joint is only capable of opposition, that is, of alternate movements in opposite directions in the same plane. This latter class is again subdivided into (*a*) *angular ginglymus* or *hinge-joints*, when the movements are angular, as in flexion or extension: the angular ginglymus is said to be *perfect*, when these movements alone are possible, as in the elbow; and *imperfect*, when a slight degree of lateral motion may take place, as in the knee: (*b*) *lateral ginglymus* (or diarthrosis trochoides), when rotation is the only possible movement. It also is subdivided into *simple*, when the bones touch only by one point; and *double*, when they have two points of contact.

The *synarthroses*, or immoveable joints, have been divided according to the nature of their articular surfaces into, 1. *suture*, when they are furnished with teeth, by means of which they are locked together, as in the *squamous suture*; 2. *harmonia*, when the surfaces are nearly smooth, and are merely in juxtaposition; 3. *gomphosis*, when one part is implanted in another, as the teeth in the alveoli; 4. *schindylesis*, when a plate of one bone is received into a groove of another: in this way the osseous projection of the anterior edge of the palate bone is attached to the opening of the maxillary sinus.†

There are many advantages in the above classification, but many imperfections also. I would characterise as especially objectionable, the class arthrodia, which comprises the most dissimilar articulations, as the shoulder joint, the articulations of the lower jaw, of the wrist, of the bones of the carpus, and of those of the tarsus. We should also notice as another cause of imperfection,

* This kind of articulation was known to Galen, and named by him *neuter*, or *doubtful articulation*.

† [The rostrum of the sphenoid, and the descending plate of the ethmoid, are united in this manner to the vomer, and afford, perhaps, a better example.]

the want of unity in the basis of the classification, which is sometimes founded upon the shape of the surfaces, sometimes on the motions.

By adopting the shape of the articular surfaces alone, as a basis, we shall find the arrangement of the ligaments and the motions to be in some measure dependent upon this. On this principle we shall divide all the joints into three classes: 1. the *diarthroses* (διάρθρον) *, or those which are formed by bones, the surfaces of which are contiguous, but free; 2. *synarthroses* (σὺν, with), or all the joints whose surfaces are continuous; 3. *amphiarthroses*, or *symphyses*, (ἄμφω, both), or those joints whose surfaces are partly contiguous, and partly continuous by means of fibrous tissue.

I. *Diarthroses.*

Characters. Contiguous or free articular surfaces, shaped so as to fit exactly upon each other, and each provided, 1. with an incrusting layer of cartilage; 2. with synovial membranes; 3. with peripheral ligaments; joints always moveable. This class is divided into six subdivisions: —

1. *Enarthrosis.*

Characters. A head, or portion of a sphere, more or less completely received into a cavity. Examples: *hip and shoulder joints* (*fig.* 76. and *figs.* 69 and 70.).

Ligaments. A fibrous capsule.

Motions. In every direction; viz. flexion, extension, abduction, adduction, circumduction, and rotation.

2. *Articulation by mutual Reception.*

Characters. Articular surfaces concave in one direction, convex in the direction perpendicular to the first, and so fitted as to embrace each other reciprocally. Example: *articulation of the trapezium with the first metacarpal bone* (*m*, *fig.* 75.).

Ligaments. Two or four ligaments, or rather an orbicular or capsular ligament.

Motions. In all directions, like the enarthroses, excepting rotation.

3. *Articulation by Condyles, or Condylarthrosis.*

Characters. An elongated head, or *condyle*, received into an elliptical cavity. Examples: *articulation of the fore-arm and hand* (*fig.* 75.), *of the lower jaw and the temporal bone* (*fig.* 65.).

Ligaments. Two or four ligaments.

Motions. In four directions; viz. flexion, extension, abduction, and circumduction, but no rotation. There are always two principal movements in these joints.

4. *Trochlear Articulation, or Ginglymus.*

Characters. A mutual reception of the articular surfaces. The pulley or trochlea belongs to this mode of articulation. Examples: *the elbow* (*figs.* 71 and 72.) *the knee* (*fig.* 78.), *the joints of the phalanges* (*figs.* 73 and 74.).

Ligaments. Two lateral ligaments always placed nearer the side of flexion than that of extension.

Motions. Two motions in opposite directions.

5. *Trochoid Articulations.* †

Characters. An axis received into a ring, which is partly osseous, and

* The particle διὰ always signifies separation.

† The trochoid (τρέχω, to turn), or pivot joint, corresponds to the simple or double lateral ginglymus of modern anatomists, or the rotatory diarthrosis of the ancients.

partly fibrous. Examples: *articulation of the atlas and axis* (*e, fig.* 64.), *of the radius and ulna* (*figs.* 71 and 72.).

Ligaments. An annular ligament.

Motions. Rotation.

6. *Arthrodia.*

Characters. Articular surfaces, plane, or nearly so. Examples: *articulations of the carpal and tarsal bones* (*figs.* 75 and 84.), *and of the articular processes of the vertebræ* (*g, figs.* 61 and 63.).

Ligaments. Fibres placed irregularly round the joint.

Motions. Gliding.

II. *Synarthroses.*

Characters. Articular surfaces armed with teeth or other inequalities, which are mutually dovetailed, and from which the name of *suture* is derived. Examples: *articulations of the bones of the cranium* (*figs.* 21, 22, and 23.).

Means of union. Remnant of the cartilage of ossification, which is gradually encroached on during the progress of age.*

There are no incrusting cartilages, synovial membranes, ligaments, nor motions.

Monro enumerates seven kinds of sutures, and these might still be multiplied, if we regarded all the varieties presented by the articular surfaces. Three kinds may be admitted with propriety: 1. *indented sutures;* 2. *squamous sutures;* and 3. *harmonic sutures;* the distinctions depending upon the articular surfaces being provided with teeth, or overlapping like scales, or being simply rough and in juxtaposition. These even are only unimportant varieties. Monro added the schindylesis, or ploughshare articulation of Keil. We shall content ourselves with simply mentioning it; and we also omit the division gomphosis (γόμφος, a nail), which is appropriated to the mode of implantation of the teeth; because the teeth are not bones, and are lodged in the jaw, not articulated with it.

III. *Amphiarthroses, or Symphyses.*

Characters. Flat, or nearly flat, articular surfaces, which are partly in contact, and are partly continuous by means of fibrous tissue. Examples: *articulation of the bodies of the vertebræ* (*b, fig.* 58.), *symphysis pubis* (*e, fig.* 77.), *sacro-iliac symphyses* (*b, fig.* 76.).

Means of union. Interosseous and peripheral ligaments.

Motion. Very slight, gliding; an arthrodia is a necessary element of an amphiarthrosis. Thus, in the symphysis pubis the bones are partly in contact, partly continuous.

ARTICULATIONS OF THE VERTEBRAL COLUMN.

Articulations of the vertebræ with each other.— Those peculiar to certain vertebræ.— Sacro-vertebral, sacro-coccygeal, and coccygeal articulations.— Articulations of the cranium — of the face — of the thorax.

The articulations of the vertebral column (*figs.* 58, 59, and 60.) are divided into the *extrinsic* and the *intrinsic.* The first comprise the articulations of the vertebral column with the head, the ribs, and the ossa innominata. The intrinsic comprise the articulations of the vertebræ with each other. These last are also divided into those which are *common* to all the vertebræ, and those which are *peculiar* to some. We shall describe each in succession.

* Some anatomists have rejected this kind of articulation, adopting the opinion of Columbus, who affirms that there can be no joint where there is no motion.

Articulations of the Vertebræ with each other.

Mode of preparation. Remove completely all the soft parts which s the vertebral column; saw off vertically all that part of the head whi front of the column, and separate the bodies of the vertebra from the p arches by dividing the pedicles. When the section reaches the axi the instrument behind the superior articular processes of this vertebra the atlas, and behind the condyles of the occipital bone: remove th marrow and its membranes. In this way the vertebral column will be into two parts,—an anterior, formed by the series of the bodies of the v on which we find the *anterior* and *posterior common ligaments*, and the i *tebral substances*; and a posterior, formed by the series of laminæ, a articular and spinous processes. The intervertebral substances requir cial preparation, which consists in making vertical and horizontal secti portion of the column, or which may be more simply effected by ma in diluted nitric acid, which allows the bodies of the vertebræ to be re without injuring the intervertebral substance. The vertebræ are unite their bodies; 2. by their articular processes; 3. by their laminæ; an their spinous processes.

Articulation of the Bodies of the Vertebræ.

The bodies of the vertebræ are united together by *amphiarthrosis.* ' throdial portion, or the contiguous surface, is represented by the a processes.

The *articular surfaces* are the upper and under surfaces of the body vertebra. It follows from the concavity of these surfaces, that, instea ting each other exactly, they leave considerable lenticular spaces b them; these appear to be the vestiges of the biconical cavity between t tebræ of fishes. The depth of these spaces is not the same through entire column; it exactly measures the thickness of the intervertebr stance. The articular surfaces are covered by a very thin layer of car

The *means of union* are of two kinds, as in all the amphiarthroses:— surround the joint; 2. they proceed from one articular surface to the in one word, some are peripheral, and the others interosseous.

1. *Peripheral ligaments.* The most general idea which can be formed ligaments is that of a fibrous sheath, surrounding the column formed bodies of the vertebræ, and uniting in one whole the different pieces of it is composed. The part of the sheath which covers the anterior aspe bones is called the *anterior common ligament of the vertebræ*; and that whic the posterior surface is called the *posterior common ligament of the verteb*

The *anterior common vertebral ligament* (*a*, *figs.* 58. 60.) presents the ance of a white pearly-looking membrane stretch the axis to the upper part of the sacrum. Th ment, which is thicker in the dorsal region than neck or the loins, is composed of three very parts,—a thick one in the middle, and two lateral are separated from it by a series of openings th passage to some vessels (see *fig.* 58.). Its *anter face* is in contact with the organs of the neck, t rax, and the abdomen, and united with them l loose cellular tissue. The tendons of the longi c anterior recti muscles, and the pillars of the diap mix their fibres with this ligament. The psoæ r correspond to its lateral portions below. Its *p surface* adheres more closely to the interverteb stances, and to the projecting rims of the bodie vertebræ, than to the transverse grooves of the

Fig. 58.

This ligament is composed of several planes of fibres, of which th

superficial are the longest. The deepest pass from one vertebra to the next, the superficial stretch over four or five vertebræ.

Posterior common vertebral ligament (*a*, *fig.* 59.). This is thicker than the anterior, but has the same white pearly appearance. It commences at the occipital bone, and terminates at the sacrum. It resembles a fibrous band, which expands at the intervertebral substances, and is contracted over the bodies of the vertebræ; hence it has a regular festooned appearance. Its *posterior surface* is united to the dura mater at its upper part, but is separated from it by a delicate cellular tissue throughout the rest of its extent. Its *anterior surface* adheres intimately to the intervertebral substances; it is separated from the middle of the bodies of the vertebræ by the veins, which pass from the interior of the bone into the vertebral venous sinuses which run along the edges of the ligament. Like the anterior common vertebral ligament, it is composed of several planes of fibres, the posterior of which are the longest. It is formed of more compact tissue than the anterior.

Fig. 59.

2. The *intervertebral substance* or *interosseous ligament* (*b*, *figs.* 58, 59, 60. and 68.) consists of a kind of disc, which fills up the lenticular space between the bodies of the vertebræ, and might with propriety be called *intervertebral disc*.

Each disc has the form of a double convex lens, and is so closely united by its *upper* and *under surfaces* to the corresponding vertebræ, that it is easier to break the bones than to destroy this connection. Its *circumference* adheres to the anterior and posterior common ligaments, and contributes to form the intervertebral foramina. In the dorsal region it also forms part of the angular facette which articulates with the ribs. The *thickness* of the intervertebral substance is not the same in all the regions of the spinal column, being greatest at the lower parts. The proportion between the thickness of the discs and the bodies of the vertebræ is not the same in all the regions. In the lumbar region the thickness of the disc is half that of the corresponding vertebræ; in the dorsal region it is a third; and in the cervical region it is a little more than a half.*

The intervertebral substance is not equally thick throughout. From its lenticular form it must be thicker in the centre than at the circumference; in the neck and in the loins it is thicker in front than behind; in the back the opposite prevails, and by this inequality the discs concur in producing the alternate curves of the vertebral column. Abnormal curvatures are in a great measure caused by unequal thickness of these discs, and I have often had opportunities to convince myself that compression of this substance on the side towards which the inclination takes place is the most common origin of the deformity. The thickness of the discs varies in different circumstances. Thus, after prolonged standing in the erect posture, the height of the body becomes diminished from eight to ten lines, which is owing to compression of the intervertebral substances.

Each disc is composed of concentric layers (*figs.* 60. and 68.) closely pressed together at the circumference, but more separate towards the centre, where we find a soft spongy substance, moistened by a viscid fluid resembling synovia. This soft substance is nearer the posterior than the anterior aspect of the body of the vertebra; it escapes, and forms as it were, a hernia, when the parts are cut either horizontally or vertically. It varies much at different ages. It is moist, soft, spongy, and white in the infant and in youth, which accords with the suppleness of the vertebral column at that period of life. At this time, also, we may inflate an irregular cellular cavity in it, which may be regarded as the rudiment of the large synovial cavity which these parts

* A curious preparation may be made, by taking away all the bodies of the vertebræ in a spine softened by nitric acid. A column then remains, formed by the series of discs, which may be compared with a column formed by the bodies of the vertebræ

exhibit in fishes. In old age it becomes dry, friable, and yellowish or brown. Monro attributes the elasticity of the vertebral column to the displacement of this soft central substance in the different movements; for, according to his theory, the movements of the bodies of the vertebræ take place upon it as upon a moveable pivot or a liquid fulcrum.

The intervertebral substance is called a *cartilaginous ligament* by Vesalius; by others a *cartilage*; and by Bichat a *fibro-cartilage*; but they evidently belong to the fibrous tissues. This may be shown by macerating a portion of the spinal column for some days, or even by rubbing the surface with a rough cloth. It will then appear that this pretended fibro-cartilage is nothing more than a series of concentric fibrous layers, strongly compressed together: that each layer is formed of parallel fibres, directed very obliquely from the lower surface of the vertebra above to the upper surface of the vertebra below, and regularly crossing with the fibres of the next layer (*b'*, *fig.* 58.). This regular crossing, which we shall meet with in other parts, is evidently very conducive to solidity.

Union of the Articular Processes.

These articulations are *arthrodiæ*.

Articular surfaces. The corresponding surfaces are covered by a thin layer of cartilage. The means of union consist of some irregular ligamentous fibres (*d d*, *fig.* 60.), which surround the outside of the joint, and are more numerous in the dorsal and cervical regions than in the loins. These articulations are provided with synovial membranes of greater extent in the cervical than in the other regions.

Union of the Laminæ.

The spaces between the vertebral laminæ are occupied by ligaments of a particular description, which are called *yellow ligaments*, *ligamenta subflava*, on account of their colour. They are composed of two halves united at an angle like the laminæ (*c c*, *fig.* 60.). Their *lower edge* is implanted upon the upper edge of the laminæ below, and their *upper edge* is attached to the anterior surface of the corresponding laminæ. From this it follows, that the *height* of the ligamenta subflava is much greater than would be necessary to reach from one lamina to another; it is almost equal to that of the corresponding vertebral lamina.

Fig. 60.

Their length is measured by that of the laminæ, and is consequently greater in the neck than in the back and loins. They are of greater *thickness* in the loins than in the back and the neck, and the thickest part corresponds to the base of the spinous process. There are also some reinforcing bundles, which constitute a sort of median yellow ligament. Their *anterior surface* is separated from the dura mater by cellular tissue, and by veins. It is remarkable for its smooth and polished appearance. Their posterior surfaces are in contact with the vertebral laminæ, which cover them almost completely, except in the cervical region, where they may be seen between the laminæ, when the head is slightly inclined forwards; this circumstance renders it possible for a penetrating instrument to enter between the cervical laminæ, while it is almost impossible in the dorsal and lumbar regions.

Structure. These ligaments are composed of parallel vertical fibres very closely arranged. They are extensible, and, when stretched, immediately recover themselves, and are therefore very elastic. They are as strong as ordinary ligaments. Their extensibility is brought into action during flexion of the vertebral column, and their elasticity during extension. They have great effect in maintaining the erect posture, which would otherwise have required a constant expenditure of muscular power.

Union of the Spinous Processes.

The spinous processes are united by the supra-spinous and the inter-spinous ligaments. The *supra-spinous ligament* (*d d*, *figs.* 58 and 59.) is a fibrous cord, which extends from the seventh cervical vertebra to the sacrum, along the summit of the spinous processes of the dorsal and lumbar vertebræ. This ligament can be only distinguished from the aponeurotic fibres, which are inserted into the spinous processes, by the longitudinal direction of its fibres. It is larger in the lumbar than in the dorsal region. It is expanded, and becomes even sometimes cartilaginous in the interval between the processes. It is inextensible. I regard a fibrous cord which extends from the seventh cervical vertebra to the external occipital protuberance, as a continuation of the supra-spinous ligament; it appears to be the vestige of the *posterior cervical ligament* of quadrupeds, and is of considerable size in some subjects; from its anterior surface, prolongations are given off to the spinous processes of all the cervical vertebræ, excepting the first.

The *inter-spinous ligaments* (*e e*, *fig.* 58.) do not exist in the neck, where their place is supplied by small muscles; they are very thin in the back, where each has the form of a triangle with the base looking backwards. They are thick and quadrilateral in the loins. Their upper and lower edges are attached to the corresponding spinous processes. Their surfaces are in contact with the muscles of the vertebral grooves. M. Mayer speaks of synovial capsules, which he has met with between the lumbar spinous processes, and especially between the third and the fourth in this region; these membranes are by no means constant.

Articulations peculiar to certain Vertebræ (*figs.* 61 to 64.).

Although the articulations of the atlas and of the axis, with the occipital bone, belong to the external articulations of the vertebral column, yet the connection between these articulations and that of the atlas with the axis is so intimate, that it is impossible to separate them. We shall describe these three articulations in succession; first noticing the articulation of the atlas with the occipital bone (*occipito-atlantoid articulation*).

Occipito-atlantoid Articulation.

Preparation. Remove the part of the skull which is in front of the vertebral column, taking care to leave the basilar process. The muscles which surround the joint, being closely applied to the ligaments, should be very carefully detached.

The atlas unites with the occipital bone, 1. by its anterior arch; 2. by its posterior arch; 3. by the base of its transverse processes; 4. by its two articular surfaces.

1. The anterior arch of the atlas is united to the circumference of the foramen magnum by two *anterior occipito-atlantal ligaments*. One of these, the *superficial* (*a*, *figs.* 61 and 64.) is a very strong cylindrical cord situated in the median line, where it forms a very marked projection, and stretches from the basilar process of the occipital bone to the anterior tubercle of the atlas. The other (*b*, *fig.* 61.), which is *deep-seated*, is pretty thick, consists of several layers, and extends from the upper edge of the anterior arch of the atlas to the occipital bone.

Fig. 61.

2. Most anatomists admit the existence of a ligament stretching from the

posterior part of the foramen magnum to the upper edge of the posterior arch of the atlas, the *posterior occipito-atlantal ligament* (*b*, *figs.* 62 and 64.). But it can scarcely be distinguished, consisting only of a few ligamentous fibres among the fat of this region.

Fig. 62.

3. *Lateral occipito-atlantal ligaments* (*c*, *fig.* 61.). A fibrous cord passes from the base of the transverse process of the atlas to the jugular process of the occipital bone. In connection with a similar bundle from the pars petrosa, it forms a very remarkable fibrous canal, which gives passage to the internal jugular vein the internal carotid artery, the hypoglossal, pneumogastric, glosso-pharyngeal, and accessory nerves.

4. The union of the condyles of the occipital bone with the superior articular surfaces of the atlas is a *double condyloid articulation*. The articular surfaces of the occipital bone are the two condyles, convex, oblong, looking downwards and outwards, and directed forwards and inwards, so that their axes if prolonged would meet in front of the basilar process. The articular surfaces of the atlas are concave and oblong, and look upwards and a little inwards, so as to fit exactly upon the convexity of the condyles. Both are covered by a thin layer of cartilage. The *ligaments* are vertical fibres which surround the joint, but are most numerous in front and on the outside, for they scarcely exist on the inside and behind. There is also a very loose *synovial membrane* which passes beyond the articular surfaces on all sides, but especially to the outside.

Atlanto-axoid Articulation.

Preparation. After having studied the superficial ligaments, remove the laminæ of the axis, the posterior arch of the atlas, and the back part of the foramen magnum. Detach with care that portion of the dura mater which corresponds to the two first vertebræ and the foramen magnum, and turn it upwards. Lastly, in order to obtain a good view of the articulation of the odontoid process with the atlas, disarticulate the occipital bone.

This articulation is formed between, 1. the odontoid process of the axis, and the anterior arch of the atlas; 2. between the superior articulating processes of the axis and the inferior articulating processes of the atlas; 3. in addition, the anterior and posterior arches of the atlas are united to the axis by two ligaments — the anterior and the posterior *atlanto-axoid ligaments*.

The *anterior atlanto-axoid ligament* (*b*, *figs.* 61 and 64.) is a thick vertical bundle composed of several layers, which extends from the tubercle and the lower edge of the anterior arch of the atlas in front of the base of the odontoid process of the body of the axis. It is continuous below with the anterior common ligament.

The *posterior atlanto-axoid ligament* (*c*, *figs.* 62 and 64.) is a very loose and thin membrane, extending from the posterior arch of the atlas to the upper edge of the laminæ of the axis; it is a little thicker in the median line than at the sides, and represents the ligamenta subflava in a rudimentary state.

Articulation of the odontoid process with the atlas. This is a *pivot* joint, the odontoid process being received into a ring formed in front by the anterior arch of the atlas, on the sides, by the lateral masses of the same bone, and behind by the transverse ligament. We have therefore to consider, 1. the articulation of the anterior arch of the atlas with the odontoid process (*atlanto-odontoid articulation*); 2. the articulation of this same process with the transverse ligament (*syndesmo-odontoid articulation*).

1. *Atlanto-odontoid articulation* (*e*, *fig.* 64.). The articular surfaces are an oval and slightly concave facette on the posterior surface of the anterior arch

of the atlas (1); and a slightly convex, vertically oblong facette, on the fore part of the odontoid process (2). Both surfaces are incrusted with cartilage, and there is also a very loose synovial membrane with subjacent adipose tissue. The joint is strengthened by some ligamentous fibres, arranged in the form of a capsule.

2. *Syndesmo-odontoid articulation.* This joint is formed by means of the *transverse* or *annular ligament* (*f*, *figs.* 63 and 64.), a very thick and compact bundle of fibres, flattened before and behind, and stretched transversely between the lateral masses of the atlas, passing behind the odontoid process, and closely embracing it like a half ring. The *anterior surface* of this ligament is concave, and polished like cartilage; it is in contact with the posterior surface of the odontoid process (2, *fig.* 64.), which is covered with cartilage, and is almost always furrowed transversely, *i.e.* in the direction of its movements. There is a very loose synovial membrane in this joint, which is prolonged on the sides of the odontoid process, as far as the odontoid ligaments. The *posterior surface* is covered by the posterior occipito-axoid ligaments* (*o*, *fig.* 64.; see *figs.* 63 and 64.). From its *upper edge* a fibrous band is detached, which is fixed to the occipital bone, in front of the occipito-axoid ligament, by a narrow extremity. Another fibrous band (see *figs.* 63 and 64.) of greater length than breadth proceeds from its *lower edge*, and is attached to the posterior surface of the axis; hence the name *crucial* has been given to the annular ligament by some authors. The extremities are inserted into two tubercles on the inside of the lateral masses of the atlas.

Fig. 63.

There is a very remarkable circumstance connected with this ligament, viz. that its *lower circumference* belongs to a smaller circle than its *upper*, so that the odontoid process is very firmly retained in the ring which this ligament contributes to form, and this arrangement accords with a sort of constriction at the base of the odontoid process.

Union of the Articular Processes of the Atlas and the Axis.

This is a double *arthrodia.* The *articular surfaces* of the atlas are plane, circular, and horizontal, but looking slightly inwards; those of the axis are also plane and horizontal, looking slightly outwards, and of greater extent than the preceding. They are retained in their place by a *fibrous capsule* (*g*, *figs.* 61. and 63.), which is very strong, especially in front, and sufficiently loose to permit the extensive motions which take place at this joint: it is formed of vertical and parallel fibres. The *synovial capsule* is very loose, and projects beyond the surfaces of the bones in every direction, but particularly in front. It almost always communicates with the synovial membrane of the joint between the transverse ligament and the odontoid process.

Union of the Occipital Bone and the Axis.

Although the occipital bone and the axis are nowhere contiguous, and are not, therefore, articulated, yet they are united very firmly by means of strong ligaments, extending from the occipital bone to the body of the axis, and also to the odontoid process.

Preparation. Remove with care that portion of the dura mater which corresponds to the first two vertebræ; the occipito-axoid ligaments lie under it. Then detach the transverse ligaments, remove the anterior arch and lateral masses of the atlas, so that nothing remains excepting the occipital bone and the axis.

* If the student is only provided with one preparation for the examination of all these joints, it is necessary to study these ligaments before dividing them, in order to expose the transverse ligaments.

1. The *occipito-axoid ligaments* are three in number, a middle and two lateral

Fig. 64.

The *middle occipito-axoid ligament* (*o*, *fig.* 64.) is thick, and forms at its upper part a single band, the fibres of which are separated below into three very distinct layers. The most posterior of these is continuous with the posterior common ligament; the second is attached to the posterior surface of the body of the axis; and the deepest, which is very thin, and shaped like a tongue pointed above, is that which we described with the transverse ligament. The *lateral occipito-axoid ligaments* (*r*, *fig.* 64.) arise from the sides of the basilar groove by a broad extremity, and are attached to the posterior surface of the axis by a pointed end. They correspond in front with the odontoid and transverse ligaments, and behind with the dura mater.

2. The *odontoid ligaments* are three in number, a middle and two lateral. The *middle* (*l*, *fig.* 64.) consists of ligamentous fibres, which extend from the apex of the odontoid process to the fore part of the foramen magnum, between the condyles; the *two lateral* (*l*, *fig.* 63.) are two bundles of fibres, very strong, short, and cylindrical, which stretch between the sides of the apex of the odontoid process, and two small fossæ on the inside of the condyles; their direction is horizontal, so that they represent the horizontal limbs of the letter T, of which the odontoid process forms the vertical portion; they are almost always united by a bundle, which passes above the odontoid process without adhering to it, so that, at first sight, they might be declared to be one and the same ligament.

Sacro-vertebral, Sacro-coccygeal, and Coccygeal Articulations.

Sacro-vertebral articulation. This resembles in every point the articulations of the other vertebræ. We shall only remark, 1. the great thickness of the intervertebral substance, particularly in front, a vertical section of it resembling a hatchet with the broad part turned forwards; 2. the *sacro-vertebral ligament* (*a*, *fig.* 76.), which is proper to this articulation, a very short, thick, and strong bundle stretched obliquely from the transverse process of the fifth lumbar vertebra to the base of the sacrum, where it crosses with some ligamentous fibres of the sacro-iliac articulation.

Sacro-coccygeal articulation. This is an amphiarthrosis, or symphysis, analogous in every respect to that of the bodies of the vertebræ; a fibrous disc resembling the intervertebral substances, but of a more loose texture, unites the corresponding articular surfaces. In some subjects the coccyx is very moveable, and there is a synovial capsule in the centre of the disc. The other means of union are, 1. the *anterior sacro-coccygeal ligament* (*a*, *fig.* 77.), composed of parallel fibres extending from the anterior surface of the sacrum to the anterior surface of the coccyx, and often divided into two lateral bundles; 2. the *posterior sacro-coccygeal ligament*, which is fixed above to the edges of the notch which terminates the sacral canal, and is prolonged upon the posterior surface of the coccyx. This ligament, which completes the sacral canal, gives attachment to the glutæi maximi muscles by its posterior surface. It is composed of several layers, the most superficial of which reach the apex of the coccyx, while the deepest extend only to the first piece of that bone.

The *coccygeal articulations* are also amphiarthroses, which become synarthroses during the progress of life. The articulation of the first with the second piece is the only one which remains to an advanced age. It is sometimes extremely moveable. *

* I have met with an instance in which this joint was very moveable: there was a synovial membrane and a fibrous capsule. The extent of motion was so great, that the two pieces could be made to form a right angle with the cavity looking backwards.

Mechanism of the Vertebral Column.

The vertebral column being at once an enclosing and protecting cylinder for the spinal marrow, a column for transmitting the weight of the trunk and the upper extremities to the legs, and an organ of locomotion, its anatomical structure must be examined in reference to these three uses.

The Vertebral Column considered as the protecting Cylinder of the Spinal Cord.

The vertebral column performs the office of a protecting cylinder, by virtue of its solidity, ensured by the bodies of the vertebræ in front, by the projection of the spinous processes behind, which ward off, so to speak, all external objects, and by the prominence of the transverse processes at the sides. By means of these arrangements, the spinal cord is inaccessible, excepting by a sharp instrument, which might penetrate either in front through the intervertebral substances, or on the sides through the intervertebral foramina, or, lastly, behind through the intervals between the spinous processes, and between the laminæ. Another condition of solidity is provided by the number of pieces of which the vertebral column is formed. For in all cases, where the column is subjected to shocks, each articulation becomes the seat of a decomposition of the force; a part is employed in producing a slight displacement of the articular surfaces, and is therefore entirely lost as far as regards the transmission of the shock. If, on the contrary, the vertebral column had been formed of one single piece, the transmission of shocks would have been unbroken, and thus the frequent cause of concussion and fracture. Lastly, the breadth of the articular surfaces by which the bodies are united, the strength and pliability of the intervertebral substances, the vertical direction of the articular processes, contrasted with the horizontal direction of the articular surfaces of the body, and the species of dove-tailing which results from it, are also most favourable conditions for the protection of the spinal marrow.

The Vertebral Column, considered as an Organ for transmitting the Weight of the Trunk.

The anatomical arrangements adapted to this purpose are the following:—

1. The progressive increase in size of the vertebral column, from the apex to the base. This disposition is particularly observable in the first two pieces of the sacrum, which are proportionally much larger in man than in the lower animals.

2. The articulation of the vertebral column with the posterior part of the pelvis, by which the centre of gravity of the trunk is carried backwards, and the maintenance of the equilibrium is aided, by counter-balancing the weight of the thoracic and abdominal viscera, which, instead of uniformly surrounding the column, are all placed in front.

3. The alternate inflexions of the vertebral column, which allow more extensive oscillations of the centre of gravity of the column, than would have been practicable had its direction been altogether rectilinear, and which also augment its power of resistance in the vertical direction.

4. The length of the spinous processes, which thus afford a more favourable, because a longer lever to the extensor muscles, which maintain the column erect. The absence of these processes in infancy is one of the causes of the difficulty of standing at that period.

5. The existence of the soft matter in the centre of the intervertebral discs, which prevents compression of the column by affording a liquid, and therefore almost incompressible *point d' appui*, as Monro has remarked; the truth of this may be proved by submitting a portion to powerful compression. It is generally believed, it is true, that the diminution of height, which follows

upon prolonged standing or walking, is the result of mechanical compression of the intervertebral discs, and an absolute diminution of their thickness; but it appears more conformable to the laws of physics to admit, that the diminution in the height of the vertebral column depends upon the increase of the curvatures, unless we admit Monro's hypothesis of the absorption of part of the liquid contained within the discs.

6. The presence of the yellow ligaments, which by their elasticity continually oppose the causes which tend to bend the body forwards, and which are for each of the vertebræ what the posterior cervical ligament is for the head.

7. The existence of the vertebral canal, which has the same advantage as the cylinder of long bones, of increasing the strength without increasing the weight.

8. The mode of articulation of the vertebral column with the head, which is doubly advantageous, both as regards the place occupied by the articular surfaces, and their direction: 1. The articular surfaces correspond to the point of junction of the posterior with the two anterior thirds of the head. The posterior third of the head contains a large portion of the encephalic mass, while the two anterior thirds are chiefly formed by the face, which, in comparison to its size, is of little weight. From this it follows, that the weight of the posterior third almost counter-balances that of the two anterior thirds of the head. 2. The almost horizontal direction of the condyles in the human subject permits the head to rest upon the summit of the vertebral column, without having a necessary tendency, or at least a very slight one, to incline forwards, as invariably takes place in animals whose occipital condyles are vertical, and situated entirely on the back of the head. Yet, notwithstanding these advantageous conditions of the atlantal articulation, the part in front of the condyles is somewhat heavier than that behind; and this difference, though slight, is sufficient to cause flexion of the head, when left to itself, either during sleep or after death.

The Vertebral Column considered as an Organ of Locomotion.

The vertebræ perform upon each other certain oscillatory or balancing movements in all directions, by means of the pliability of the intervertebral substances*; but they are so obscure, that their existence can scarcely be recognised, or their character examined on a small portion of the column. In order to understand them, the entire spine must be examined.

Movements of the entire column. These are, 1. Flexion, or the movement forwards; 2. Extension; 3. Lateral inclination; 4. Circumduction, in which the column describes a cone, of which the apex is below, and the base above; 5. Rotation on its axis, or torsion of the vertebral column.

In the analysis of the motions of the column, it is necessary to distinguish carefully between the actual and the apparent motions; the first are much less extensive than would be imagined at first sight, the greater part of the apparent movements taking place at the articulations of the pelvis with the thighs. In these movements of the whole, the column represents a lever of the third order, an elastic arch in which the resistance is at the upper extremity, the fulcrum at the lower end, and the power applied in the middle. Each vertebra, on the contrary, represents a lever of the first order, in which the power and the resistance are at the anterior and posterior extremities of the bone, and the fulcrum in the middle.

1. *In the movement of flexion*, which is the most extensive of all, the anterior common ligament is relaxed; the anterior part of the intervertebral substances is compressed; the soft central portion is pushed backwards; the posterior fibres of the discs are slightly stretched, as are also the posterior common ligament, the supra-spinous, inter-spinous, and yellow ligaments. The in-

* Thus the uniting media of the vertebræ serve also as means of locomotion.

ferior articular processes of each vertebra move upwards upon the superior articular processes of the vertebra below. The laminæ are separated, so that the rachidian canal, especially in the cervical region, becomes accessible to penetrating instruments.

2. *In extension*, the anterior common ligament and the anterior fibres of the intervertebral discs are stretched; the posterior fibres of the disc are relaxed; the soft central matter is pushed forwards; the yellow, supra-spinous, and inter-spinous ligaments are relaxed. The lower articular processes glide downwards upon the superior articular processes of the vertebra below. This motion is not extensive; it is limited by the anterior common ligament, and the meeting of the spinous processes.

3. In the movements of *lateral inclination*, the discs are compressed on the side to which the inclination takes place, and the central pulp is forced to the other side. These motions are limited, not only by the meeting of the transverse processes, but even before these touch, by the resistance of the intervertebral substances, and of the lateral bundles of the anterior common ligament.

4. *Circumduction.* This motion, the centre of which is in the lumbar region, appears at first sight very extensive, because a portion of the movement at the hip joint is generally ascribed to it. In reality, it is very limited, and results from a succession of the preceding motions.

5. The movement of *rotation* is effected by the twisting of the intervertebral substances. Although the motion of each disc is very slight, yet the simultaneous twisting of them all produces a general movement, by which the anterior surface of the column is turned slightly to the sides. It is however, upon the whole, very limited; and although in the erect posture the trunk of the body can describe a semicircle, the greater part of this motion takes place at the hip-joint.

All the regions of the vertebral column do not equally participate in these general motions. They are most extensive in the *cervical region*, where we observe, 1. *flexion*, which may be carried so far as to make the chin touch the upper part of the sternum; 2. *extension*, so that the neck may be turned backwards; 3. *lateral inclination*, until the head nearly touches the shoulder; 4. *rotation*, which is greater here than in any of the other regions, notwithstanding the presence of the lateral hook-like processes or ridges.* These motions may be to such an extent as to cause luxation, which can only take place, without fracture, in the cervical region, on account of the almost horizontal direction of the articular processes.

The general movements are most limited in the *dorsal region*. 1. Flexion is rendered impossible by the presence of the sternum. The presence of this bone in the different species of animals attests the immobility of the dorsal portion of the column, in the same manner as its absence is an indication of its mobility. 2. Extension is prevented by the meeting of the spinous processes, which are longer and more closely imbricated in this than in any other of the regions. 3. Lateral movements are rendered impossible by the ribs, which would be forced against each other if this motion took place. 4. As all the preceding motions are the elements of circumduction, it may be easily conceived that this can scarcely take place. 5. The same obstacles oppose the movement of rotation, which is also prevented by the position of the articular processes, which are directed vertically, and whose surfaces on the right and left sides are not upon the same plane. The thinness of the intervertebral substances in the dorsal region accords with all these arrangements in limiting mobility.

What has been said regarding the immobility of the dorsal region applies only to the upper part of this region. The dispositions at the lower part are

* We should form an incorrect notion of the obstacle resulting from the lateral ridges on the bodies of the vertebræ, in the performance of rotation, if we were to study them only on the disarticulated skeleton. In the recent subject they scarcely touch the vertebra above, on account of the intervertebral disc.

more favourable to mobility. We know, that the two last dorsal vertebræ are remarkable for the shortness of their spinous and transverse processes; and that the ribs with which they articulate are very moveable, and could not oppose the motions of the vertebræ in any degree.

The *lumbar region* participates much more in the general motions than the dorsal. The articular processes in this region are much more advantageously adapted for rotation than in either the dorsal or cervical, for the lower pair of each vertebra forms a solid cylinder, which is received into the hollow surface of the superior articulating processes of the vertebra below. This arrangement permits a motion resembling that of the hinges of a door.

It should be remarked, that in all the regions the lower articular processes of each vertebra are placed behind the superior articular processes of the succeeding vertebra, and form a sort of imbrication. Each vertebra then is retained in its place by a species of dove-tailing, so that it cannot be dislocated forwards, without breaking the superior articular processes of the vertebra below, nor backwards, without breaking the inferior articular processes of the vertebra above. This remark does not apply rigorously to the cervical region, the articular processes of which are oblique, and can permit dislocation without fracture.

Mechanism of the Articulations of the Vertebral Column and the Head.

The movements of the head upon the vertebral column are shared between two articulations: viz. 1. the occipito-atlantal, to which all the motions of flexion, extension, lateral inclination, and circumduction belong; 2. the atlanto-axoid, which only performs one movement, viz. rotation.

Mechanism of the Occipito-atlantal Articulation.

The movements of flexion and extension of the head upon the atlas are very limited; when the head is decidedly bent or inclined, the effect is produced by motion of the whole cervical region. It is possible to distinguish flexion at the occipito-atlantal articulation from that which is produced by the entire cervical region. In the first case the chin approaches the vertebral column, and the skin on the upper part of the neck is wrinkled transversely; in the latter the spine bends at the same time as the head, consequently the interval between it and the chin remains the same, and there are no transverse wrinkles of the skin.

During flexion the condyles glide backwards; the odontoid, the occipito-axoid, and the posterior ligaments are stretched, but in extension the gliding takes place in an opposite direction.

The occipito-atlantal articulation is deprived of the power of rotation by the direction of the condyles, which mutually obstruct this movement. In birds, which have only one condyle, the articulation of the head admits of very extensive rotation. In the human subject there is a slight movement of rotation at this joint, when the head is previously inclined upon one of the condyles, which then serves as a pivot.

Mechanism of the Atlanto-axoid Articulation.

In the movements of this articulation we should regard the atlas and the head as forming only one piece. There are no movements either of flexion or extension. The inclusion of the odontoid process in the syndesmo-atlantal ring prevents even the slightest motion of the atlas, either forwards or backwards; for in the forward motion, or flexion, the atlas is fixed by the transverse ligament which presses upon the odontoid process; and in the backward motion, or extension, the atlas is fixed by its own anterior arch, which is brought in contact with the same obstacle. There is, moreover, no lateral inclination at this joint, for this is prevented by the odontoid ligaments. Rotation is, there-

fore, the only movement which remains. In this motion, in which the head describes the arc of a large circle upon the vertebral column, the syndesmo-atlantal ring turns upon the axis as a wheel upon its axle. Of the two plane surfaces of this joint, one glides forwards, and the other backwards · one of the odontoid ligaments is stretched, and the other relaxed. These ligaments, it should be observed, limit the extent of rotation; but their resistance is occasionally insufficient, and the odontoid process breaking one of them slips below the transverse ligament, and occasions death by compressing the spinal cord. Luxation, therefore, of this articulation is to be dreaded, not merely for the same reasons as other dislocations, but as being a cause of compression of the spinal marrow.

The entire movement by which the face is turned to either side should not be attributed to this articulation alone, for it extends to the fourth of a circle on each side, and such a degree of motion would dislocate the articular surfaces of the atlas and the axis.

Articulations of the Cranium.

All the bones of the cranium are united together by synarthroses. We have here to examine, as in all other articulations, 1. the articular surfaces; 2. the means of union. As the bones of the cranium form a complete cavity, closed in every direction, they unite by their entire circumferences or by their edges: and as the solidity of joints is in a direct ratio to the extent of the articular surfaces, the bones of the cranium, which are only in contact by their edges, would have been very slightly connected, had it not been for the following provisions: 1. The cranial bones are generally thicker at the circumference than in the centre; 2. They are almost all provided with marginal denticulations that multiply the points of contact; 3. The edges, instead of being cut perpendicularly, are bevelled so as to overlap each other, and thereby present much more extensive corresponding surfaces; 4. We should observe, also, the number of projecting and retreating angles that are formed by these bones; and 5. the sinuous arrangement of their edges.

We should remark, however, that these different modes of ensuring solidity are not employed indiscriminately over the whole skull. In the vault of the cranium, for example, firmness is attained by the mutual adaptation of the serrated margins of the bones at the upper and at the back parts, and by their overlapping at the sides; in the base, on the contrary, the solidity chiefly depends upon the breadth of the contiguous surfaces, and upon the reception of projecting into corresponding retreating angles. Examples of this double arrangement may be seen in the articulation of the occipital and sphenoid bones, which is accomplished by means of broad surfaces, and in the articulation of the projecting angle formed by the petrous portion of the temporal bone with the retreating angle formed by the occipital bone behind, and the sphenoid in front.

This description will suffice to give a general idea of the mode of union between the bones of the cranium. It would evidently exceed the limits of this work to dilate upon the form of each of the sutures and to follow Munro, in distinguishing fourteen or fifteen different kinds. Nevertheless we do not think a few words regarding the principal forms of the indentations will be out of place. We would therefore observe, that the tooth-like projections are sometimes four or five lines in length, and are themselves indented on their edges, secondary denticulations being thus formed. They are generally straight, but are sometimes alternately bent towards the external and the internal surface. Some of the teeth are as it were pediculated, and are enclosed between the others, thus holding a middle place between the Wormian bones and the ordinary denticulations.

We should remark that the name suture, properly speaking, belongs more especially to those sutures in which the bones are dove-tailed; that those sutures

the uniting surfaces of which are broad and oblique, are generally called squamous; and that the harmonic articulations are those in which the indentations are scarcely perceptible. We must also observe, 1. with regard to the sutures, that their indentations are much deeper on the external than on the internal surface of the bones of the cranium; 2. with regard to those sutures which are bevelled, that they often present alternate oblique sections having opposite directions, so that of two bones the one that overlaps the other at one part of the suture is at another part itself overlapped: of this we have an example in the fronto-parietal suture.

Means of Union of the Bones of the Cranium.

We have remarked, in speaking of the development of the bones, that those which are subsequently united by immoveable articulations are formed in a piece of cartilage that is common to them all. Portions of this cartilage, not yet encroached upon by ossification, serve as the uniting media. It is evident, therefore, that these cartilages of the sutures are broader when the amount of ossification is less, viz. in the earlier periods of life. The pericranium on the outside, and the dura mater on the inside, contribute also to strengthen the union of the bones of the cranium.

Mechanism of the Cranium.

What has been said above of the immobility of the bones of the cranium is not equally true at all periods of life. During fœtal existence, and the first few years after birth, the intervals between the bones of the cranium are occupied by a flexible cartilaginous substance, which permits those of the roof to move pretty extensively upon each other. Since, therefore, the conditions of solidity are not the same at this period as in the adult, we must examine the mechanism of the cranium both in the fœtus and in the adult.

1. In the fœtus the conditions of solidity must be studied both in the roof and in the base of the cranium.

In the roof of the cranium the incomplete ossification allows the bones to move upon each other, and in this respect the encephalon is imperfectly protected. But on the other hand, the presence of these cartilaginous intervals diminishes the momentum of a violent force applied to the cranium, and thus prevents, in some degree, both fractures of the cranium and concussions of the brain. The mobility of the bones is principally displayed at birth, in their overlapping when the head of the fœtus is passing through the pelvis. The base of the cranium is incompressible at the same period, and the bones are immoveable, because ossification has so far advanced, that they are only separated by very thin layers of cartilage. This arrangement is well adapted for the protection of the most important parts of the encephalon, which are in the vicinity of the base of the cranium.

2. In the adult the roof and the base of the cranium form one piece. The roof being most exposed to violence, we shall examine the mechanism of resistance in the cranium to blows directed vertically upon the top of the head; and it will be easy to apply what is said in explanation of the effects of a force so directed to cases in which violence is applied in other directions.

The effects which may be presumed to follow a violent blow on the top of the skull are, 1. Concussion of its bony parietes, succeeded by their elastic reaction; 2. Disjunction of the pieces entering into the formation of the skull; and 3. Fracture of those pieces. We shall examine the method in which these results may be produced.

1. *Concussion and compression of the cranium without fracture.* The cranium may be looked upon as a hollow sphere, endowed with a certain degree of elasticity, depending partly upon the osseous tissue itself, and partly upon the cartilaginous laminæ which separate the bones; and it cannot, therefore, be doubted

that from pressure, or violent blows on the top of the head, the skull may undergo a flattening, and then recover its original condition, like a hollow ball of ivory when struck vertically. The truth of this explanation may be shown at once by projecting a skull against a resisting surface, when it will be found to rebound like an elastic ball. However slight this flattening may be, and the recovery which follows it, the known laws of physics will not allow us to deny its possibility.

2. *Tendency to disjunction of the bones of the cranium.* This separation has never been observed as the consequence of external blows. The following is the manner in which displacement is prevented in cases of blows on the top of the head. It is evident that violence applied in this direction would have a tendency to depress the upper edge of the parietal bones; but this cannot take place without forcing the lower edge outwards: and as from the peculiar formation of the squamous suture the parietal bones are overlapped by the temporal and the sphenoid, this edge cannot be driven outwards without giving the temporal bones such a motion as will tighten the articulations of the base of the cranium. All these articulations are remarkable in this respect, that the projecting angles of some of the bones are received into the retiring angles of others. This is exemplified in the articulation of the petrous portion of the temporal bone with the sphenoid and the occipital bone, and in the basilar process of the occipital bone with the two temporals and the sphenoid. The result of all these arrangements is, that blows upon the top of the head, instead of separating the bones of the cranium, tend to render their union still closer.

3. Another effect of blows on the top of the head may be fracture of the cranial bones; and it will be impossible to comprehend the nature of many of these fractures, without a knowledge of the following points of structure: 1. The cranium is of unequal thickness in different parts. This circumstance explains how a round body, striking the cranium in a spot of sufficient strength to resist the impulse, may cause a fracture of a more or less distant part, where the parietes are thinner and consequently weaker. It may be conceived, that this kind of fracture may take place either in the bone struck, or in other bones, and that it may affect the internal table only, the external remaining uninjured. 2. The cranium is so constructed, that a shock impressed upon the top is concentrated at the base, being propagated on the sides to the temporal bones and their petrous portions, as well as to the great wings of the sphenoid and the body of that bone; behind, by the occipital bone to the basilar process and the body of the sphenoid; and in front, by the frontal bone and the roof of the orbits, to the smaller wings and body of the sphenoid. It will thus be seen how blows upon various parts of the skull may concentrate their effects upon the base of the cranium; and this explains the production of fractures at the base, in consequence of violence inflicted on the roof of the skull. 3. Most of the cranial bones are bent and angular. This disposition which is observed at the union of the orbital and frontal portions of the frontal bone, and at the junction of the squamous and petrous portions of the temporal bone, explains how these bones may be broken by the transmission of shocks from the roof. For we may conceive, when violence is applied to a bone which is bent at an angle, that this angle will be the seat of a decomposition of the force, one portion of which is transmitted to the part of the bone below the angle, whilst the remaining portion acts against the angle itself in the original direction, and may thus determine a fracture of that part of the bone.

Although the roof of the cranium is most exposed to injury, yet some parts of the base may be reached by penetrating weapons, as the roof of the orbits and the cribriform plate of the ethmoid. It should be remarked, also, that these are the thinnest parts of the skull.

Articulations of the Face.

The articulations of the face comprise those of the upper and of the lower jaw.

Articulations of the Bones of the Superior Maxilla with each other, and with the Cranium.

All these articulations are sutures, but they have not such large indentations as the bones of the cranium; almost all are united by harmonia or juxta-position. At the same time it should be remarked that a true dovetailing exists in these articulations, as may be seen in the junction of the superior maxillary bones (the fundamental articulation of the face), which is effected by means of thick furrowed surfaces, mutually and firmly adapted to each other.

No suture in the whole skull is stronger than that between the malar and the maxillary bones; indented sutures are most common on the sides of the face. The manner in which the vertical portion of the palate bone is received into the furrow in the opening of the maxillary sinus, affords an illustration of the suture by reception. There are some well-marked indentations in the articulations of the bones of the face with those of the cranium; as in the articulation of the nasal bones; of the ascending processes of the superior maxillæ; and of the malar bones with the frontal; in that of the sphenoid with the malar bones; and of the latter with the zygomatic processes of the temporal bones. Simple juxta-position is met with in the junction of the ethmoid with the roof of the orbit; of the palate bone with the pterygoid processes; and of the vomer with the ethmoid; but there is a mutual reception in the articulation of the vomer with the sphenoid.

With regard to the means of union, in addition to the firm union resulting from the configuration of the articular surfaces, there is also a thin layer of cartilage, continuous with that which formed the matrix of the bones, and which is itself afterwards obliterated during the progress of ossification.

Mechanism of the Articulations of the Upper Jaw.

As the mechanism of the face is adapted both to resist force applied from below through the medium of the lower jaw, and also the effects of external violence, it is necessary to analyse the conditions of solidity resulting from the configuration of the upper jaw; and in order to appreciate these correctly, we must analyse the frame-work of the face.

The upper jaw, considered as a whole, forms inferiorly a sort of parabola, circumscribed by the alveolar border, which is the strongest part of the bone, and receives the direct impulse of the lower jaw: it curves backwards, and forms the roof of the palate, which gradually diminishes in thickness; and, not receiving the impulse of the lower jaw directly, its construction is not so solid as the alveolar border. The upper jaw becomes broader and flattened above, and separates into different parts or prolongations, which, after enclosing certain openings, unite with the cranium, by means of several processes, that form, as it were, so many columns for resisting any impulses transmitted from below.

These columns are, 1. the fronto-nasal, constituted on each side by the ascending process of the superior maxillary bone. These columns, which correspond to the canine teeth, are remarkably strong in carnivorous tribes; and to their great size may be attributed the lateral position of the orbits in these animals. The interval between these columns is occupied above by the nasal bones; but an opening is left between them, below, shaped like a heart on playing cards. The whole of that portion of the alveolar edge situated beneath this opening is weaker; but it should be remarked, that it corresponds to the incisor teeth, which, being adapted for cutting, divide instead of bruising or tearing the food, and are consequently not subject to such powerful efforts as the canine and molar teeth.

2. The second pair of columns is formed by the malar eminences, which are continuous with the alveolar border, by the vertical ridge separating the canine from the zygomatic fossa. These columns, which correspond to the second great molar teeth, may be called the zygomato-jugal, because they are subdivided into two other secondary columns, the vertical, malar, or jugal, and the horizontal or zygomatic. The *jugal columns* are much stronger than the fronto-nasal, and are continuous with the external orbital processes of the frontal bone, and with the anterior thick and indented edges of the great wings of the sphenoid: the second, or horizontal, articulate with the zygomatic processes of the temporal bones, and with them constitute the *zygomatic arches.* From this arrangement it may be understood, how effectually the bevelling of the end of the zygomatic process that rests upon the malar bone, is adapted for resisting impulses communicated from below. The zygomatic arches, also, form props that oppose all transverse displacements. The mode of articulation of the zygomatic processes with the malar bones is such, that the zygomatic arches, although horizontal, are well calculated to resist any force from below. In carnivora, where there are no jugal columns, the zygomatic arches are enormously large.

The fourth pair of columns are the *pterygoid,* intended to support the face in the antero-posterior direction: being articulated with the maxillary bones, through the medium of the palate bones, these also oppose any displacement upwards, and, moreover, serve to support the back part of the alveolar border.

There are, therefore, four pairs of columns; viz. the *fronto-nasal,* the *jugal,* the *zygomatic arches,* and the *pterygoid columns.* They are almost entirely composed of compact tissue. The principal columns are situated immediately above the first great molares, where the jugal, zygomatic, and pterygoid columns are concentred, and where the most violent impulses are received. The fronto-nasal columns correspond to the canine teeth; their strength is proportioned to that of these teeth, and hence in carnivorous animals the ascending processes of the superior maxillæ are very large and thick. The fronto-nasal and jugal columns are near each other below, and only leave a small space between them, which is occupied by the two small molares; but they are separated to a considerable distance above, and enclose the orbital fossæ.

In this manner the deep fossæ in the face are formed without being prejudicial to its strength. Even the maxillary sinus does not much diminish the solidity of the face, because it is situated in the interval between the columns, and because only a small portion of it corresponds to the alveolar border.

These details will suffice to show, that the upper jaw has been framed to resist external impulses, but especially forces communicated from below by the lower jaw; that the alveolar border, being intended to receive the impulse directly, is most strongly constructed; that the whole force applied to the upper jaw is transmitted by the fronto-nasal columns to the internal orbital processes, by the malar columns, partly to the external orbital processes, and partly to the zygomatic arches, and by the palate bone to the pterygoid columns of the sphenoid; that the vomer transmits little or nothing either to the ethmoid or the sphenoid; and that the cranium, on its part, opposes very unyielding structures to the sustaining pillars of the face. To forces directed from before backwards, the zygomatic arches and the pterygoid processes offer great resistance; against lateral violence each malar bone resists like an arch, and transmits the impulse it has received to the superior maxillary bone, the frontal and the sphenoid. The greatest part of the impulses communicated to the face are then ultimately transmitted to the cranium; and were it not for the multiplicity of its constituent parts, and the great number of articulations which absorb part of the force, the brain contained within it would be frequently exposed to dangerous violence. The upper jaw is concerned in the process of mastication merely as a means of support; for though it may be raised when the mouth is opened, and depressed when the mouth is

shut, these movements belong to the entire head, and result from the action of its extensor muscles, which thus become powerful auxiliaries of mastication in the carnivorous animals.

Temporo-maxillary Articulation (*figs.* 65, 66, and 67.).

This joint, the centre of all the movements of the lower jaw, is a double *condyloid articulation.* The *articular surfaces* are, 1. the two condyles of the lower jaw, transversely oblong, and directed somewhat obliquely inwards and backwards, so that their axis if prolonged would intersect behind: 2. the glenoid cavity of each temporal bone, and the transverse root of its zygomatic process. These surfaces are covered with cartilage.

The glenoid cavity is remarkable, both for its depth and its capacity. Its depth is increased by several eminences on its borders; viz. on the inside, by the spine of the sphenoid; and behind, by the styloid and the vaginal processes, the latter of which is nothing more than the anterior lamina of the auditory meatus. The capacity of the glenoid cavity is no less remarkable, being double or triple that which would be necessary to receive the condyle; moreover the whole of this cavity is not articular, the part situated behind the glenoidal fissure being extraneous to the joint. This disproportion between the cavity and the condyle is only observed in man and in ruminantia: in rodentia and carnivora, the one is exactly proportioned to the other. The portion of the glenoid cavity posterior to the fissure affords an example of those *supplementary cavities* that in certain circumstances increase or replace the principal cavity. All that part of the glenoid cavity situated anteriorly to the fissure, belongs to the joint, and is therefore covered with cartilage.*

The *transverse root* of the zygoma, convex from before backwards, and concave transversely, is also articular, and covered by a cartilage, which is a continuation of that lining the glenoid cavity. This articulation presents the only example in the body of two convex surfaces moving upon each other.

The means by which motion is facilitated, and union maintained in this articulation, are an inter-articular cartilage, an external lateral ligament, and two synovial membranes; the internal lateral ligament of some authors, and the stylo-maxillary ligament, do not belong to this joint.

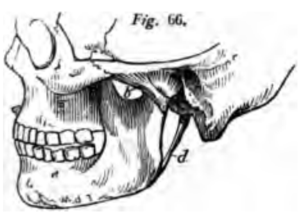
1. *Inter-articular cartilage* (*a*, *fig* 65.). This cartilage is interposed between the articular surfaces; it is thick at the circumference, and sometimes perforated at the centre, and resembles a bi-concave lens, with this peculiarity, that its upper surface is alternately convex and concave to correspond with the glenoid cavity and the transverse root of the zygoma, while the lower surface is concave and adapted to the condyle. Its circumference is free, excepting on the outside, where it adheres to the external lateral ligament, and on the inside where it gives attachment to some fibres of the external pterygoid muscle. This circumstance is of great importance in regard to the mechanism of the joint. The existence of an inter-articular cartilage in a joint which is subjected to such considerable pressure, and is so often put in motion, agrees with the general law already pointed out. (Vide THE ARTICULATIONS IN GENERAL.)

Fig. 65.

2. *External lateral ligament* (*b*, *fig.* 66.). This ligament extends from the

* The study of the condyle and the glenoid cavity is of very great importance in comparative anatomy; for by the characters which they present, we may easily recognise the head of one of the rodentia, carnivora, or ruminantia. 1. In carnivora, the condyles are transversely oblong, the long axes of both being in the same line; they are received into very deep cavities. 2. In rodentia, on the contrary, the long diameter of the condyles is directed from before, backwards. 3. In ruminantia, the glenoid cavity is flat, as well as the head of the condyle, whilst the transverse root of the zygoma is scarcely discernible.

tubercle situated at the junction of the two roots of the zygoma, to the outside of the neck of the condyle: it is directed obliquely downwards and backwards, and forms a thick band covering the whole of the outside of the articulation: it is in contact with the skin externally, and internally with the two synovial capsules and the inter-articular cartilage.



Anatomists have described under the name of the *internal lateral* or *spheno-maxillary ligament* (*c*, *fig.* 67.) an aponeurotic band, which neither as regards its position or its use, can be considered as properly belonging to the joint; it is extended from the spinous process of the sphenoid, to the spine situated on the inside of the orifice of the inferior dental canal. It is a very thin band which covers the inferior dental vessels and nerves, and separates them from the pterygoid muscles. Since the band just described has no effect in giving strength to the joint, it may be wondered that there is only one ligament for the articulation; but it should be observed that, as the lower jaw is articulated in the same manner at both its extremities, the external lateral ligament of the one exactly performs the functions of an internal lateral ligament to the other.

The *stylo-maxillary ligament* (*d*, *figs.* 65, 66, and 67.) appears to me to hold the same place as the preceding; it is a fibrous band extending from the styloid process to the angle of the inferior maxilla. It has no relation to the union of the articular surfaces. Its use appears to be that of giving attachment to the stylo-glossus muscle; Meckel calls it the stylo-mylo-hyoid ligament.

3. There are two synovial capsules in this joint, one on the upper, and the other on the lower surface of the inter-articular cartilage (see *fig.* 65.). Sometimes they communicate by an opening in the cartilage; the superior is looser than the inferior; and thus the articular cartilage is more closely united to the condyle of the lower jaw than to the glenoid cavity.

These two synovial capsules are in contact on the outside with the external lateral ligament, and elsewhere with a thin layer of fibrous tissue.

Mechanism of the Temporo-maxillary Articulation.

In considering the action of this joint, the lower maxilla may be regarded as a hammer which strikes against the anvil represented by the upper jaw; it is a double angular lever, the axis of its motion being represented by a horizontal line that would pass through the middle of the rami. This articulation, which belongs to the class of condyloid joints, has been ranged among the angular ginglymi, on account of the great extent of its movements in two opposite directions, during its elevation and its depression, but it differs from them in being so constructed as to admit of slight lateral movements. It can also be moved forwards and backwards.

1. *Depression.* In this movement each condyle rolls forwards in its glenoid cavity, and then passes upon the transverse root of the zygoma, with a sudden jerk, which may be easily felt by placing the finger on the condyle whilst the mouth is being opened, at the same time the angle of the jaw is moved backwards. The condyle carries with it the inter-articular cartilage; for the union of these two parts is of such a nature that, even in dislocation of the jaw, they are never separated. This depends not only upon the comparative tightness of the lower synovial capsule, but also on the mode of insertion of the external pterygoid muscle, which being attached both to the neck of the condyle and

the inter-articular cartilage, acts simultaneously upon them. The other parts of the joint are affected in the following manner:—during depression of the lower jaw, the external lateral ligament is stretched; the upper synovial capsule is distended behind, but readily yields on account of its laxity. The spheno-maxillary band, or internal lateral ligament, which is inserted at an almost equal distance from the condyle which is carried forwards, and from the angle of the jaw which is carried backwards, remains unaltered, being neither stretched nor relaxed.

When the depression is carried too far, either from the effect of a blow upon the bone, or during a convulsive yawn, the condyle is dislocated into the zygomatic fossæ, tearing the superior synovial capsule, and carrying with it the inter-articular cartilage.* This mode of displacement is impossible in the infant, for from the obliquity of the ascending ramus of the jaw the upper part of the condyle looks backwards, and in order to be luxated forwards would have to traverse a much larger space than it does even when the mouth is opened to the greatest possible extent.

2. *In elevation*, the condyle rolls backwards upon the transverse process into the glenoid cavity. The external lateral ligament is relaxed. The obstacles to too great an elevation are, 1. The meeting of the dental arches; 2. The presence of the vaginal process, and the anterior wall of the auditory meatus; and it is very probable that the extensive movements of the jaw in the old subject when the teeth are lost, are permitted by the size of the glenoid cavities. Without that portion of the glenoid cavity which is behind the fissure of Glasserus, the toothless alveolar edges of the aged could never be brought in contact.

The *forward motion* is not, like the preceding, the motion of a lever in which the jaw turns upon its axis; it is a horizontal movement in which the condyle is brought under the transverse root of the zygoma. A preliminary and indispensable condition to this movement is a slight depression of the whole of the lower maxilla. In this movement all the ligaments are stretched; if it were carried too far, the coronoid process would strike against the bone in the zygomatic fossa, and this circumstance would prevent the possibility of luxation of the condyle.

The *backward motion* requires no special remark.

The *lateral movements* differ from the preceding in the mechanism by which they are effected. In the first place, the whole bone does not move from its place. One of the condyles alone escapes from its socket, while the other remains in the glenoid cavity. The bone, therefore, turns upon one of the condyles as on a pivot.

The external lateral ligament of that articulation in which the condyle moves is much stretched.

The lateral motions would have been much more extensive, had not the two condyles mutually obstructed each other, in all movements but that of depression, by reason of their opposite directions. This may be shown by sawing a maxilla through the middle, and moving each of the halves. Moreover, the styloid and vaginal processes and the spine of the sphenoid prevent displacement inwards.

Articulations of the Thorax.

The articulations of the thorax comprehend, 1. the costo-vertebral articulations; 2. the chondro-sternal; 3. the articulations of the cartilages of the ribs with each other; 4. the junction of the cartilages and the ribs.

* This luxation would be much more common were it not for the inter-articular cartilage, which, by always accompanying the condyle, presents a smooth surface, over which the latter may glide in returning into its proper cavity.

The Costo-vertebral Articulations (*figs.* 58. to 60. and 68.).

Preparation. Saw the ribs across at their posterior angles. Remove with care the pleura and the subjacent cellular tissue in front, and the muscles of the vertebral grooves behind. After having studied the superficial ligaments, expose, 1. the costo-transverse interosseous ligament by a horizontal section of the rib, and the transverse process to which it is attached; 2. the costo-vertebral interosseous ligament by a similar horizontal section, including one vertebra and one rib, and passing above the angular part of the joint. This last ligament may be also exposed by a vertical section of the rib and the two vertebræ with which it is connected. The costo-vertebral articulations have some characters which are common to them all, and others that are peculiar to a few.

General Characters of the Costo-vertebral Articulations.

Articular surfaces. In this joint the head of the rib is applied to the angular surface formed by the two half facettes (*ff'*, *fig.* 58.) upon the sides of the bodies of the dorsal vertebræ, so that each rib is articulated with two vertebræ (*costo-vertebral articulation, properly so called*); and in addition, the tubercle of the rib is applied to the facette (*g*, *figs.* 58. 60. and 68.) on the fore-part of the transverse process (*costo-transverse articulation*).

With regard to the costo-vertebral articulation, it is to be remarked, 1. that it affords an example of a projecting angular facette received into a retreating angular facette, which has given rise to the mistaken notion that this joint is an angular ginglymus; and 2. that in each articulation the lower half facette is twice as large as the upper.

The surfaces of the costo-transverse articulation are, a convex facette belonging to the tubercle of the rib, and a concave one belonging to the transverse process. Sabatier affirms that the articular surfaces of the transverse processes look forwards and upwards in the upper vertebræ, and forwards and downwards in the lower, and directly forwards in those which occupy the middle of the column. This arrangement has been referred to in explanation of the mechanism of the dilatation of the thorax, by depression of the lower, and elevation of the upper ribs; but this explanation is unfounded.

In addition to the costo-vertebral and costo-transverse articulations, the neck of the rib (*c*, *fig.* 68.), without being in immediate contact with the transverse process, is in some degree united with it by symphysis.

Means of union. These joints are examples both of symphysis and arthrodia. Some of the ligaments are external to the articulation, the remainder are interosseous.

The ligaments external to the articulation are, the anterior costo-vertebral or stellate ligament, the superior and the inferior ligaments, the posterior costo-transverse, and the superior costo-transverse.

1. *The anterior costo-vertebral, or stellate ligament* (*l*, *fig.* 58.) arises from the two vertebræ with which the rib is connected, and from the corresponding intervertebral substance. From these points its fibres converge, and are inserted in front of the extremity of the rib.

2 and 3. Besides the stellate ligament there are two small ligamentous bundles, a *superior* and an *inferior*, which extend from each of the vertebræ concurring to form the articulation, to the extremity of the rib.

4. The *posterior costo-transverse ligament* (*m*, *fig.* 59. *transverse ligament* of Boyer, *posterior costo-transverse ligament* of Bichat) is a fibrous band stretched from the apex of the transverse process in an oblique direction to the non-articular portion of the tubercle of the rib.

5. The *superior costo-transverse ligament* (*n*, *figs.* 58, 59. *costo-transverse* of Boyer, *inferior costo-transverse* of Bichat) consists of a band, which arises from the lower edge of each transverse process, passes obliquely, and is inserted, not into the rib, which articulates with tnat process, but into the upper edge of the

neck of the rib below. At the place of this insertion, we always find a crest or spine. This ligament is sometimes divided into two or three bundles; it forms the continuation of a thin aponeurosis, which covers the external intercostal muscle, and completes the external wall of the opening through which the posterior branches of the intercostal vessels and nerves are transmitted. This ligament is interposed between the anterior and posterior branches of these vessels and nerves.

The *interosseous ligaments* are two in number. 1. A costo-vertebral interosseous; 2. A costo-transverse interosseous.

1. The *costo-vertebral interosseous ligament* (*o, fig.* 58.) is a small bundle of fibres, very short and very thin, extending horizontally from the projecting angle on the head of the rib to the retreating angle of the vertebral facette, where it is continuous with the intervertebral substance.

2. The *costo-transverse interosseous ligament* (*a, fig.* 68.) is formed by some ligamentous bundles intermixed with reddish adipose tissue, which stretch from the anterior surface of the transverse process to the posterior surface of the neck of the rib. An idea of the strength of this ligament may be formed by attempting to separate the rib from the transverse process, after the anterior costo-vertebral and the posterior costo-transverse ligaments have been divided.

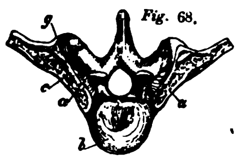


Fig. 68.

There are three *synovial capsules* in the articulations of the ribs with the vertebræ, — one between the tuberosity and the transverse process, and two small ones for the two surfaces which are separated by the costo-vertebral interosseous ligament.

Characters peculiar to certain Costo-vertebral Articulations.

The articulations of the first, eleventh, and twelfth ribs alone present peculiarities.

1. *Costo-vertebral articulation of the first rib.* The rounded head of the first rib is received into a cavity on the side of the body of the first dorsal vertebra; the articulation is therefore a species of enarthrosis; there is neither a costo-vertebral interosseous ligament, nor a superior costo-transverse ligament: the synovial membrane is much looser than in the corresponding articulations.

2. The *costo-vertebral articulations of the eleventh and twelfth ribs* present the same characters as the preceding in this respect, that the articular cavity for the head of the bone is situated upon one vertebra alone. The head of the rib is flattened, or very slightly convex; and there is no interosseous costo-vertebral ligament. The superior costo-transverse ligament is much broader and stronger than in the other articulations. As the eleventh and twelfth ribs have no tuberosities, and the transverse processes of the corresponding vertebræ are but little developed, it follows that there is no costo-transverse articulation; but yet there is a costo-transverse interosseous ligament. All these ligaments are much more loose than in the other articulations.

The Chondro-sternal Articulations (*fig.* 69.).

These are seven in number on each side, formed by the internal angular end of the cartilages, which are received into the angular cavities on the side of the sternum. The means of union are, 1. a *radiated* or *anterior chondro-sternal ligament* (*a, fig.* 69.), which is tolerably strong: it crosses in the median line with the corresponding ligament of the opposite side, and is blended both with the periosteum and the aponeurotic insertions of the greater pectoral muscles, in the thick fibrous layer which covers the sternum; 2. two small ligaments, a *superior and an inferior;* 3. a *radiated* or *posterior chondro-sternal ligament*, much weaker than the anterior. The existence of a synovial membrane is merely inferred from analogy, for it cannot be demonstrated. (Vide ARTICULATIONS IN GENERAL.

The first, second, sixth, and seventh, chondro-sternal articulations present some peculiarities. 1. The cartilage of the first rib is sometimes continuous with the sternum, and is sometimes articulated like the cartilages of the other ribs. I found in one subject the first rib excessively moveable, because its cartilage, instead of being continuous with the sternum, had its upper edge applied to the side of that bone to which it was united by ligaments, and was ultimately articulated by a narrow extremity immediately above the second rib. 2. The second cartilage (*b*) is much more angular at its inner extremity than any of the others: it is received into the retreating angle formed by the union of the first two pieces of the sternum. Sometimes there is an interosseous ligament in this joint, running from the angle of the cartilage to the bottom of the cavity, and there are then two synovial capsules; in other cases there is only one (*c*), but it is always more marked than in the other joints. 3. The articulations of the sixth and seventh cartilages, besides the anterior ligaments, have also a *chondro-xiphoid ligament*, more or less strong, which crosses with the ligament of the opposite side in front of the ensiform cartilage and the lower end of the sternum. Sometimes this ligament only exists for the seventh cartilage; it is intended not only to strengthen the chondro-sternal articulations, but also to maintain the xiphoid appendix in its place.

The Chondro-costal Articulations.

The cartilages are immoveably united to the ribs; the anterior extremity of the rib is hollowed to receive the external end of the cartilage; there is no ligament. The periosteum is the only bond of union, as in the articulations of the cranial bones.

The Articulations of the Costal Cartilages.

The first, second, third, fourth and fifth, costal cartilages do not articulate together, unless the aponeurotic laminæ, sometimes very strong, which form the continuation of the external intercostal muscles, and occupy the whole length of the cartilages, be considered as uniting media.

The sixth seventh, and eighth cartilages, frequently the fifth, and sometimes the ninth, present true articulations. Some cartilaginous processes arise from the neighbouring edges, and come in contact with each other: there are sometimes two articular facettes between the sixth and the seventh cartilages. The means of union are some vertical fibres united in bundles so as to form two ligaments, the one anterior and thicker, the other posterior and thinner. There is a much more distinct synovial membrane than in the chondro-sternal articulations. The seventh, eighth, and tenth cartilages have not always articular facettes, but are simply united by vertical ligaments.

Mechanism of the Thorax.

As the thorax performs the double office of protecting the organs which it incloses, and of assisting by its movements in the function of respiration, we must consider its mechanism with reference to both these ends.

Mechanism of the Thorax, for the Protection of the contained Organs.

1. The following is the mechanism by which the thorax is enabled to resist pressure or violent blows directed from before backwards. The sternum is supported by the fourteen ribs, which like buttresses oppose their united strength to any causes of displacement or fracture; it is therefore very rare to find the sternum driven backwards, and all the ribs broken, however great the violence may have been. The elasticity of the cartilages and of the ribs, and the number of articulations which exist in the thorax, are all circumstances most favourable to strength, because they diminish the intensity of external blows by neutralising a certain amount of impulse: yet I have met with one case, in which all the sternal ribs were broken by a fall, as completely as if the

anterior wall of the thorax had been divided for an anatomical preparation. I should remark, also, that the flexibility of the ribs and their cartilages permits great depression of the sternum without fracture; and this explains the possibility of contusion, and even rupture, of the heart, lungs, or great vessels, without fracture of the bones of the thorax. The degree of resistance of the anterior wall of the thorax may be also considerably varied, by the state of relaxation or contraction of the muscles, which should be considered as active and contractile supports to the arch, of which the sternum forms the key stone.

2. In the case of lateral pressure or blows, the thorax resists, like an arch, the vault of which is represented by the convexity of the twelve ribs, and its pillars by the sternum in front and the vertebræ behind. External violence cannot act upon the whole side of the chest at once, as it does upon the front, and therefore the ribs offer a more partial resistance laterally, and are accordingly much more easily broken by direct blows. In this case, also, as in the former, when the elevator muscles of the ribs are in action, the resistance is considerably increased; and individuals have been then able to bear enormous weights, which would, in all probability, have fractured the ribs, had the muscles been relaxed.

What has been said above of the manner in which the ribs withstand violence, is not however applicable to the false ribs, which having no fixed point on the sternum, are depressed into the abdominal cavity.

Mechanism of the Thorax, with reference to Mobility.

The thorax is not equally moveable throughout. The middle which corresponds to the heart, and is formed by the sternum and vertebral column, has a very limited degree of mobility, while the sides which correspond to the lungs are endowed with the power of extensive motion.

The movements of the thorax consist of alternate dilatations and contractions, from which its mechanism has been compared to that of a pair of bellows. They result from the motions which take place at the costo-vertebral and chondro-sternal articulations, and at the articulations of the cartilages with each other. We cannot explain the movements of each rib and of the entire thorax, without first analysing the motions at each of the above joints.

Movements of the Costo-vertebral Articulations.

These articulations permit only very limited gliding motions. In these movements, each rib represents a lever which moves upon the fulcrum afforded by the vertebral column. It may describe the movements, 1. of elevation; 2. of depression; 3. it may be carried inwards; 4. it may be carried outwards; 5. it may perform a revolving motion, around the cord of the arc which it represents. These different movements, which are very obscure in the immediate neighbourhood of the joint, are more evident the greater the distance is from the posterior end of the rib. The means of union between the ribs and vertebræ are so strong, that luxation of the ribs is impossible, and the causes which would tend to produce it would break the neck of the rib.

Each rib is capable of performing all these motions; but as they vary in degree in the different ribs, we must examine them comparatively in the series of costo-vertebral articulations. The eleventh and the twelfth ribs possess the most extensive power of motion. They owe this, 1. to the circumstance of their being scarcely at all united to the very small transverse processes; 2. to the loose state of their ligaments; and 3. to the almost perfect flatness of their articular surfaces. The extent of their movements inwards and outwards should be also noticed. We shall find these movements, but less pronounced, in the eighth, ninth, and tenth ribs, but they scarcely exist in the first seven ribs.

The shape of the head of the first rib is undoubtedly favourable to mobility,

and has suggested the idea that it is the most moveable of all the ribs; but the articulation of its tubercle with the transverse process of the first dorsal vertebra, and the tightness of its ligaments, sufficiently explain why this opinion is erroneous.

The movements which take place in the second, third, fourth, fifth, sixth, and seventh costo-vertebral articulations, do not differ sufficiently to require any special mention.

Movements of the Chondro-sternal Articulations.

In these articulations, there is even less gliding than in the preceding. The anterior extremity of the first rib, or rather of the cartilage which forms its continuation, is the least moveable of all; more commonly, it is completely fixed on account of its continuity with the sternum,—a circumstance which neutralises the favourable conditions for mobility presented by its posterior extremity. The eleventh and twelfth ribs, whose anterior extremities are connected only to soft parts, are the most moveable. The mobility of the ribs in front decreases from the lower to the upper part of the thorax; to this rule the second rib is an exception, chiefly on account of the two synovial membranes at its chondro-sternal articulation, which permit of greater motion.

Movements of the Cartilages upon each other.

The movements of this kind are restricted to the sixth, seventh, eighth, ninth, and tenth ribs, the cartilages of which alone are articulated to each other; they are simple gliding motions; and the ribs thus connected are always moved simultaneously.

Movements of the entire Rib.

The movements of the entire rib are composed, 1. of those which take place at the sternal and vertebral articulations; and 2. of those which result from its own flexibility and elasticity. We shall endeavour to reduce the subject to its most simple elements. Let us suppose, then, that the ribs are straight, inflexible levers: from their oblique position in reference to the vertical axis of the spinal column, their elevation will increase the width of the intercostal spaces; for it is a law of physics, that lines which are oblique with regard to another line, and parallel to each other, become further separated when they are placed perpendicularly to that line. A second effect of the elevation of this oblique lever is the advancement of the anterior extremity of the rib, and consequent increase of the antero-posterior diameter of the thorax. But as the ribs are curved levers, in assuming the horizontal position, their concavity must come to be directed perpendicularly to the median plane formed by the mediastinum. It may be shown geometrically, that the concavity of an arc which falls perpendicularly upon a plane, includes a greater space than when it falls obliquely.*

The arcs of the ribs, however, have not all the same curvature: each rib has its own peculiar perimeter, and it may be proved that the more curved the rib, the greater is the projection outwards which it forms when elevated. Lastly, as in some ribs the upper border forms the segment of a smaller circle than the lower, the movement of projection outwards is proportionally greater in these than in the other ribs. This assertion may be experimentally proved by imitating the movements of elevation and depression on the second rib.†

If the ribs and their cartilages were inflexible levers, the movements of elevation would be much restrained; but their flexibility admits of more extensive

* Borelli, t. ii. p. 177.

† From measurements taken by Haller, it appears that the second rib is the most elevated during inspiration; and if this may be doubted, it cannot be denied that its excentric movement is greater than that of any of the other ribs.

motions than would arise from the mobility of the articular surfaces. The result of this flexibility is a twisting motion, which occurs principally in the cartilage, and during which the rib acts like a lever. This movement of torsion or of rotation in a rib round an axis, represented by the cord of the arc which it forms, is in a direct ratio to the length of the rib and its cartilage.

We shall now examine the movements of the thorax in general.

Movements of the Thorax in general.

The general movements of the thorax which result from those partial motions we have been engaged in considering are, 1. A movement of dilatation, corresponding with the act of inspiration; 2. A movement of contraction, corresponding with that of expiration.

1. The dilatation of the thorax is caused by the elevation of the ribs. By this movement, the anterior extremity of each rib is carried forwards, and the antero-posterior diameter of the thorax is thus increased; the most excentric portion of the rib is carried outwards, and the transverse diameter of the thorax is thereby augmented. There is a sort of antagonism between the upper and lower part of the thorax, with regard to the direction in which the increase in its capacity is effected: in the upper part the transverse diameter is most augmented; in the lower, the antero-posterior diameter.

So long as the elevation of the ribs is effected through means of the costo-vertebral articulations, and the flexibility of the ribs and their cartilages, the sternum scarcely participates in the motion; but when the elevation is carried beyond a certain point, the sternum is carried upwards with the ribs; and the first rib which may be looked upon as the prop of the sternum, also participates in the motion.

The sternum does not perform an angular motion during its elevation, as Haller imagined; the whole of it is carried forwards at once, retaining its primitive direction, as Borelli had previously well pointed out.

We have as yet only spoken of the increase in the capacity of the thorax in the antero-posterior and transverse directions; its enlargement vertically is produced by a totally different mechanism, viz. the contraction of the diaphragm combined with the elevation of the ribs: we shall notice this afterwards.

2. The contraction of the thorax is effected by the depression of the ribs. This is produced, 1. by their own weight; 2. by the elasticity of their cartilages, which being no longer maintained in a twisted condition, in consequence of the relaxation of the muscles engaged in elevating the ribs, react, and restore the ribs to their original position, so that, as Haller has ingeniously remarked, the rib and the cartilage are alternately the cause of their respective movements; 3. by the action of the muscles of expiration.

ARTICULATIONS OF THE SUPERIOR OR THORACIC EXTREMITIES.

Articulations of the shoulder.— Scapulo-humeral.— Humero-cubital.— Radio-cubital.— Radio-carpal.— Of the carpus and metacarpus.— Of the fingers.

Articulations of the Shoulder.

The two bones of the shoulder are articulated together; the clavicle is also united with the sternum and the first rib. There are therefore two orders of articulations, 1. the intrinsic articulations of the shoulder, viz. the acromio- and coraco-clavicular articulations; 2. the extrinsic, or the sterno- and costo-clavicular.

The Acromio- and Coraco-clavicular Articulations.

The clavicle is articulated, 1. with the acromion by its external extremity, the *acromio-clavicular articulation;* 2. with the coracoid process by its lower surface, the *coraco-clavicular articulation.*

Preparation. Remove the skin, the cellular tissue, and the muscles which surround the joints; separate the acromion from the spine of the scapula; remove in succession the different layers of the superior acromio-clavicular ligament, so as to be able to judge of its thickness. Make a vertical section of

the acromio-clavicular articulation, so as to be able to observe the thickness of the ligaments and articular cartilages.

Acromio-clavicular Articulation (fig. 69.).

Articular surfaces. The clavicle and the acromion process oppose to each other a plane, elliptical surface, with its greatest diameter directed from before backwards. The articular surface of the clavicle looks somewhat obliquely downwards and outwards, the acromial facette looks obliquely upwards and inwards. The extent of these surfaces varies greatly in individual cases, dependent on the degree of exercise to which the joint is subjected.*

Means of union and provision for facilitating motion. These are, 1. An *inter-articular cartilage*, first pointed out by Weitbrecht; it is by no means constant, and when it does exist, occupies only the upper half of the articulation. 2. An *orbicular fibrous capsule* (*d, fig.* 69.) which is very thick above and behind, and very thin below. It is composed of distinct bundles, which are much longer behind than in front, and are strengthened by some fibres belonging to the aponeurosis of the trapezius muscle: it is not only attached to the upper edge of the articular surface, but also to some inequalities upon the upper surface of the acromion. It is composed of several layers, the deepest being the shortest. 3. A *synovial membrane*, of a very simple construction, supported below by adipose tissue.

Coraco-clavicular Articulation (fig. 69.).

There can be no doubt concerning the existence of an articulation, where two surfaces are contiguous and capable of a gliding motion on each other; one of them, the coracoid, being almost always covered with cartilage and a synovial membrane; and the other, the clavicular, presenting sometimes a considerable process.

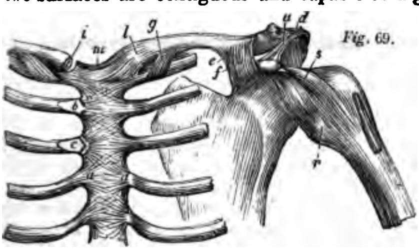


Fig. 69.

The *means of union* are two ligaments, or rather two distinct ligamentous bundles, a posterior and an anterior: they are called coraco-clavicular.

1. The *posterior ligament*, named also the *conoid* or *radiated* (*e, fig.* 69.), is triangular, and directed vertically; it commences by a narrow extremity, at the base of the coracoid process, and is inserted into a series of tubercles on the posterior edge of the clavicle near its outer extremity.

2. The *anterior ligament* (*f*) (*trapezoid ligament* of Boyer), arises from the internal edge of the coracoid process, and from the whole extent of the rough projection on the base of this process: from this it proceeds very obliquely to the ridge on the lower surface, near the external end of the clavicle.

The two coraco-clavicular ligaments are continuous, and can only be distinguished by the direction of their fibres.

We might with propriety range among the means of union of this joint an aponeurotic lamina, to which much importance has been attached in surgical anatomy, and which is known by the name of the *costo-clavicular aponeurosis* or costo-coracoid ligament. It may be easily felt under the pectoralis major in emaciated individuals: it extends from the inner edge of the coracoid process, to the lower surface of the clavicle, and converts the groove for the subclavius muscle into a canal.

* In individuals who have exercised the upper extremities very much, these surfaces are uneven, and unequally incrusted with newly-formed cartilage.

Mechanism of the Acromio- and Coraco-clavicular Articulations.

The acromio- and coraco-clavicular articulations perform well-marked gliding movements: and in addition the scapula rotates forwards and backwards upon the clavicle to a considerable extent. In order to have a correct idea of these motions and their mechanism, it is necessary to procure a shoulder with the ligaments still attached, and to rotate the scapula backwards and forwards. It will be then seen that the scapula turns round an imaginary axis passing through its middle. The looseness of the posterior half of the orbicular and of the coraco-clavicular ligaments permits this rotatory motion; of the two coraco-clavicular ligaments, one limits the rotation forwards; while the other, which, as we have observed, runs in an opposite direction, limits the rotation backwards. Although these motions are pretty extensive, they never give rise to dislocation, which can only be produced by falls on the top of the shoulder, the coraco-clavicular ligaments being lacerated if the luxation be complete. Incomplete luxations may however take place without laceration of these ligaments.

The Sterno-clavicular Articulation (*fig.* 69.).

The articulation of the inner end of the clavicle is composed of the sterno-clavicular and the costo-clavicular articulations.

Preparation. Saw through the clavicles vertically at their middle, and also the first ribs at corresponding points; and meet these two sections by a horizontal division of the sternum. In order to see the interior of the sterno-clavicular joint, open the fibrous capsule along the edge of the sternum above, or rather make a horizontal cut, which will divide it into two parts, an upper and an under.

In order to examine the costo-clavicular articulation, open the synovial membrane behind.

The *sterno-clavicular articulation* belongs to those which are formed by *mutual reception.*

Articular surfaces. The *articular surface* of the *sternum* is transversely oblong, concave in the same direction, and convex from before backwards; it looks obliquely upwards and outwards, and is situated on the side of the notch on the upper part of the sternum.

1. The *articular surface* of the *clavicle* is oblong from before backwards, slightly concave in the same direction, and convex transversely. From the respective configuration of these surfaces a mutual jointing results, and the short diameter of the one corresponds to the long diameter of the other; so that the end of the clavicle overlaps the surface of the sternum in front and behind, and the surface of the sternum projects beyond that of the clavicle on the inside and the outside.*

2. There is an *inter-articular lamina* of *cartilage* (*i*, *fig.* 69.) between the articular surfaces, which is moulded upon them, and is very thick, especially at the edges. It is sometimes perforated in the centre.† It is so closely united by its circumference to the orbicular ligament, that it is impossible to separate them: it adheres below to the cartilage of the first rib, and above and behind to the clavicle.

Means of union. These are, 1. The *orbicular ligament* (*l*, *fig.* 69.). This name may be given to the fibrous capsule which surrounds the joint in all directions. The fibres which compose it have been regarded as forming two distinct bundles, known by the name of anterior and posterior ligaments; but it is impossible to distinguish between them. Fibres proceed from all parts

* Bichat considers that this arrangement of the articular surfaces predisposes to luxation; it appears to me to have a precisely opposite effect, as it permits the surfaces to move upon each other to a considerable extent without being separated.

† In a great number of cases this ligament is found partially wasted by the continued pressure to which the joint is subjected.

of the circumference of the articular surface of the clavicle, obliquely downwards and inwards to the circumference of the articular surface of the sternum. The capsule is not of equal thickness throughout; it is thinner and somewhat looser in front than behind, which may partly account for the more frequent luxations of the clavicle forwards than backwards.

2. The *inter-clavicular ligament* (*m*, *fig.* 69.), consisting of a very distinct bundle stretching horizontally above the fourchette of the sternum, from the upper part of the inner end of one clavicle to the inner end of the other. This ligament, which is much nearer the posterior than the anterior part of the joint, establishes a sort of continuity between the clavicles. It is the only direct means of union between the two shoulders.

3. There are *two synovial capsules* in this joint. That which is between the sternum and the inter-articular cartilage is more loose than that between the cartilage and the clavicle.

The Costo-clavicular Articulation (*fig.* 69.).

The articulation between the clavicle and the cartilage of the first rib is an arthrodia. It is formed between an articular surface, which almost always exists on the lower surface of the clavicle, and a corresponding facette on the upper surface of the inner end of the first rib, at its junction with the cartilage. There is, in this articulation, a synovial membrane, which is loose, especially behind. There is only one ligament, — the *costo-clavicular* (*g*, *fig.* 96.), a thick strong bundle of fibres, quite distinct from the tendon of the subclavius muscle, which is placed in front of it. It is fixed to the inner part of the first costal cartilage, and is directed very obliquely upwards and outwards, to be inserted into the under surface of the clavicle, to the inner side of the articular facette.

Mechanism of the Sterno-clavicular Articulation.

This articulation is the moveable centre of the motions of the shoulder, and of the whole upper extremity; and hence the utility of an inter-articular cartilage, to obviate the effects of blows or pressure: hence also the wearing away of this cartilage, the deformity and wasting of the articular surfaces, the depression of the right sternal facette, and lastly the difference in the size of the sternal extremities of the right and left clavicles.

This articulation, like all those effected by mutual reception, admits of motions in every direction, — viz. upwards, downwards, forwards, backwards, — and of circumduction, resulting from the preceding, but not of rotation.

1. *Movement of elevation.* In this the sternal facette of the clavicle glides downwards upon the corresponding surface of the sternum; the inter-clavicular ligament is relaxed; the cartilage of the first rib comes in contact with the inner extremity of the clavicle, limits the degree of elevation, and prevents displacement.

2. *Movement of depression.* In this the sternal end of the clavicle glides in the opposite direction; the articular surfaces of the costo-clavicular articulation press strongly against each other, and limit the extent of this movement. It should be remarked, that in this movement the subclavian artery is compressed between the clavicle and the first rib, sometimes so completely as to arrest the circulation in the limb.

3. In the movement of the shoulder *backwards*, the inner end of the clavicle glides forwards upon the surface of the sternum; the anterior part of the orbicular capsule is stretched; and if the movement is carried beyond a certain point, the capsule is torn, and the clavicle dislocated forwards.

4. In the *forward* movement of the shoulder, the inner end of the clavicle glides backwards. The anterior part of the orbicular ligament is relaxed, and the posterior part stretched; as also the inter-clavicular ligament, which, as we have seen, is nearer the back than the front of the joint. In this motion luxation

may take place backwards. It may be remarked that, of all the movements of the shoulder the one described, in which the clavicle is liable to be dislocated backwards, is the most uncommon.

The *movement of circumduction* is more extensive forwards and upwards than backwards. The motions at the sterno-clavicular articulation are very circumscribed in themselves; but when transmitted by the lever of the clavicle, they become very considerable at the apex of the shoulder.

Mechanism of the Costo-clavicular Articulation.

This articulation, which may be regarded as a dependence of the sterno-clavicular, admits of very limited motions, subordinate to those of the joint last described.

The Scapulo-humeral Articulation (*figs.* 69 and 70.).

Preparation. Separate the upper extremity from the trunk, either by disarticulating the clavicle at its sternal end, or by dividing it through the middle; 2. Detach the deltoid from its origin; 3. Detach the supra and infra-spinati muscles, the teres minor and subscapularis, proceeding from the scapula to the humerus; 4. Observe the adhesion of the tendons of these muscles to the capsular ligament; 5. Divide the capsule transversely, after having studied its external aspect.

The scapulo-humeral articulation belongs to the class of *enarthroses.*

Articular surfaces. These are the *glenoid cavity* of the scapula, slightly concave, of an oval form with the large end downwards, and looking directly outwards, and the *head* of the humerus, consisting of about a third of a sphere, and presenting a surface three or four times more extensive than the glenoid cavity. The axis of the head of the humerus forms a very obtuse angle with that of the shaft of the bone.

These two surfaces are covered by a layer of cartilage, which, on the head of the humerus, is thicker at the centre than at the circumference; while the reverse obtains in the glenoid cavity.

Glenoid ligament (*a, fig.* 70.). This is a fibrous circle, which surrounds the margin of the glenoid cavity, and appears to be formed by the bifurcation of the tendon of the long head of the biceps; but it is also partly composed of fibres proper to itself, which stretch along the margin, arising from one point and terminating in another. Notwithstanding this addition, the head of the humerus is still too large to be received into the cavity, so that a portion of it is always in contact with the capsular ligament, an inconvenience that is obviated, in some measure, by the existence of a supplementary cavity, as we shall presently see.

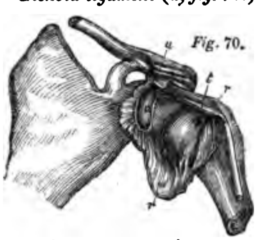


Fig. 70.

Means of union. Like all enarthroses, there is here a *fibrous capsule*, or *capsular ligament* (*r, figs.* 69 and 70.), a sac with two openings, which extends from the margin of the glenoid cavity to the anatomical neck of the humerus.* This capsule is remarkable for its laxity. In fact, it is so capacious that it could lodge a head twice as large as that of the humerus, and is so long that it will allow the articular surfaces to be separated for more than an inch; the only example of so great a separation without laceration of the ligament.†

There is this peculiarity in the fibrous capsule of the shoulder-joint, that it

* It should be remarked, however, that the fibrous capsule does not terminate directly at the anatomical neck of the humerus, but is prolonged a little downwards, and becomes blended with the insertions of the tendons of the supra and infra-spinati and subscapularis.

† In paralysis of the deltoid, the head of the humerus is so far separated from the glenoid cavity that two fingers may be inserted between the articular surfaces.

is incomplete in one part, its place being there supplied by the tendons of the surrounding muscles. In no joints, in fact, have the muscles and tendons more effect in strengthening the articulation: they are in a manner identified with it. The following are the relations of the capsule: — 1. Below, in the variable space between the subscapularis and teres minor, it corresponds to the cellular tissue of the axilla, or rather to the thin edges of the muscles just mentioned: the head of the humerus may, therefore, be easily felt by the fingers introduced deeply into the axilla. 2. Above and on the outside, it is in contact with the tendon of the supra-spinatus, and is also in relation, though not immediately, with the arch formed by the acromion and clavicle with the deltoid muscle. 3. In front, it corresponds to the subscapular muscle, from which it may be easily separated. 4. Behind, it corresponds to the tendons of the supra and infra-spinatus and teres minor, which are more or less adherent to it. As to its structure, it is composed of fibres stretched irregularly from the neck of the humerus to the circumference of the glenoid cavity. Its thickness is not great, nor is it equal throughout, being most considerable below and in front; but the capsule is strengthened above by a considerable bundle of fibres (*s*, *fig.* 69.), called the *coracoid ligament*, *coraco-humeral ligament*, or *accessory ligament of the fibrous capsule*, which arises from the anterior edge of the coracoid process, and spreads out on the capsule. This capsule almost always presents two remarkable openings, or interruptions, in the continuity of its fibres. The first, which is constant, is situated near the concave edge of the coracoid process, and establishes a communication between the synovial membrane of the joint and that belonging to the subscapularis muscle. It is of a circular form, and transmits a prolongation of the synovial capsule. The other, which is not constant, is situated near the concave surface of the acromion process; a second prolongation of the synovial capsule passes through it, and establishes a communication between that of the joint and one belonging to the infra-spinatus muscle.

Inter-articular ligament. This name may, with propriety, be applied to the tendon (*t*, *fig.* 70.) of the long head of the biceps, which, arising from the upper part of the glenoid cavity, turns like a cord over the head of the humerus, and passes along the bicipital groove. It acts by keeping the head of the humerus applied to the glenoid cavity, and forms a sort of arch that supports the bone when it is forced upwards. In two subjects, I found this tendon terminating by a strong adhesion in the bicipital groove, and thus justifying the name of inter-articular ligament, which I have applied to it: the tendon for the long head of the biceps took its origin from the same groove. I consider this division of the tendon to have been accidental, for the bicipital groove was depressed, and the inter-articular ligament flattened, and as it were lacerated.

The *synovial capsule* is remarkable, inasmuch as, 1. It forms a fold round the tendon of the biceps, which is prolonged into the bicipital groove, and terminates below by a cul-de-sac or circular fold, which prevents the effusion of the synovia; 2. It is open in one or two points*, and presents two prolongations communicating with the synovial bursæ of the subscapularis and infra-spinatus.

Supplementary cavity. We may regard as a dependence of the scapulo-humeral articulation the vaulted arch formed by the coracoid and acromion processes, and the ligament which unites them. In shape it corresponds to the head of the humerus, and is so constructed that the coracoid process prevents displacement inwards; the acromion prevents it upwards and outwards; and the ligament between them opposes dislocation directly upwards. This provision evidently compensates for the incomplete reception of the head of the humerus in the glenoid cavity.

The utility of this vault, and the frequent pressure of the head of the humerus

* [Although the synovial capsule of the shoulder-joint is thus occasionally prolonged into the bursæ mucosæ connected with the tendons of these muscles, it must not, therefore, be supposed that it is an exception to the general rule that membranes of this nature always form shut sacs; in such cases the three structures constitute one continuous cavity.]

against it, are proved by the almost constant presence of a large bursa or synovial capsule between it and the tendon of the supra-spinatus.

The Coraco-acromial Ligament.

This ligament (*u*, *figs.* 69 and 70.) forms part of the vault we have described: it is a triangular bundle of radiating fibres, which extends from the apex of the acromion to the whole length of the posterior edge of the coracoid process. Its external edge becomes thinner, and is continued into an aponeurotic lamina below the deltoid muscle, and separating that muscle from the joint. It is lined below by a synovial membrane, and is separated from the clavicle by fatty tissue.*

Mechanism of the Scapulo-humeral Articulation.

The scapulo-humeral articulation admits of the most extensive movements of any joint in the body: it is capable of every kind of motion; viz. forwards and backwards, and also those of adduction, abduction, circumduction, and rotation.

Forward and backward motions. In these the head of the humerus rolls upon the glenoid cavity, and moves round the axis of the neck of the humerus, while the lower extremity of the bone describes the arc of a circle, of which the centre is at the joint, the radius being represented by the humerus. The forward movement is very extensive, and may be carried so far that the humerus may take a vertical direction exactly opposite to the natural one. The motion backwards is produced by the same mechanism; the head of the humerus turns upon its axis. This movement is limited by the contact of the head of the humerus with the coracoid process, without which dislocation forwards would be very easily produced. It should be remarked that, in any considerable movement of the humerus forwards, the scapula is also moved, performing that sort of rotation which we spoke of when considering the mechanism of the shoulder.

The movement outwards, or *abduction*, is the most remarkable. It belongs exclusively to animals possessed of a clavicle. In it the head of the humerus does not turn upon an axis; it glides downwards upon the glenoid cavity, and presses upon the lower part of the capsule. The shape of the glenoid cavity, which has its long diameter vertical, and its broad part below, is advantageous as regards this motion. When abduction is carried so far that the humerus forms a right angle with the axis of the trunk, a great part of the head of the bone is below the glenoid cavity. If, while in this condition, the arm be moved forwards or backwards, the great tuberosity of the humerus rubs against the coraco-acromial arch, and forms with it a sort of supplementary articulation, lubricated by the bursa above described. The movement of abduction may be carried so far as to allow the arm to touch the head without dislocation; for the capsular ligament is sufficiently loose, especially below, to receive almost the whole head of the bone without being torn. It should be remarked, that during abduction, the scapula is fixed, which explains the frequency of luxations of the humerus downwards.

Adduction is limited by the arm meeting with the thorax. When it is combined with the forward motion, the upper and back part of the capsule and the muscles which cover it are considerably stretched. The scapula does not participate in this movement, during which luxation can be occasioned only by a very strong impulse on the arm upwards and backwards.

Circumduction is nothing more than the transition of the humerus from one to another of these motions. The cone which it describes is much more ex-

* [This is the *ligamentum proprium anterius* of authors; but the author has taken no notice of another ligament proper to the scapula, viz. the *ligamentum proprium posterius*, a thin band of fibres stretched across the notch at the base of the coracoid process, which it thus converts into a foramen. The supra-scapular nerve generally passes below, and the artery above it.]

ensive in front than behind, — a circumstance tending greatly to facilitate the rehension of external objects, which is the chief purpose of the upper extreiities. This predominance of the forward motions has been already noticed in he sterno-clavicular articulation, and will be found also in many others.

Rotation. In this movement the humerus does not turn upon its own, but pon an imaginary axis, directed from the head of the humerus to the epi·ochlea, parallel to the bone. The manner in which the rotatory muscles embrace ıe head of the humerus is highly favourable to this motion, by compensating ır the shortness of the neck, which serves as a lever for the rotatory movements.

[HE HUMERO-CUBITAL ARTICULATION, OR ELBOW-JOINT (*figs.* 71 and 72.).

Preparation. 1. Remove carefully the brachialis anticus muscle; 2. Detach ıe tendon of the triceps from above downwards without opening the synovial apsule; 3. Remove the muscles which are attached to the internal and external ıberosities, keeping in mind that the lateral ligaments are intimately connected ith the tendons of these muscles. This articulation belongs to the class of *ochlear joints* (angular ginglymi).

Articular surfaces. On *the humerus* we find, 1. an almost perfect trochlea or ulley, presenting two edges, of which the internal is the more prominent, so hat when the end of the bone rests upon a horizontal plane, its shaft is diected very obliquely from above downwards and inwards; 2. the small head, or articular condyle separated from the trochlea by a furrow which is also articular; 3. two cavities, a posterior which is very deep, and is intended to receive the olecranon process, and an anterior which is shallower, and receives the coronoid.

Fig. 71.

Fig. 72.

The articular surfaces of the *fore-arm* are, 1. The greater sigmoid cavity of the ulna, which exactly embraces the trochlea; 2. the glenoid cavity of the radius, which receives the small head of the humerus.

The *means of union* consist of four ligaments, — two lateral, an anterior, and a posterior. 1. The *external lateral ligament* (*a*, *fig.* 71, 72.) is blended with the tendon of the supinator brevis; it is of a triangular form, and stretches from the external tuberosity of the humerus to the annular ligament with which it becomes continuous, and which seems to be in part formed by it. Some fibres of this ligament are also inserted into the outer part of the sigmoid cavity of the ulna. This connection of the lateral with the annular ligament is of great importance, with reference to the production of luxations of the upper end of the radius.*

2. The *internal lateral ligament* (*b*, *fig.* 71.) is composed of three bundles, which comıence at the internal tuberosity of the humerus and radiate, the anterior om behind forwards to the inner side of the coronoid process, the middle ertically downwards to the inner edge of the same process, and the posterior ackwards to the inner edge of the olecranon.

3. The *anterior ligament* (*c*) is a very thin layer, in which however three rders of fibres can be recognised. The first directed vertically form a bundle

* The luxations of the radius upon the ulna in dislocations of the elbow result from this nnection of the external lateral with the annular ligament.

which extends from the upper part of the coronoid cavity to the lower part of the coronoid process; the second are transverse, and intersect the first at right angles; and lastly, the third are obliquely directed downwards and outwards to the annular ligament. *

4. The *posterior ligament* (*d, fig.* 72.). The place of the posterior ligament is occupied by the olecranon and the tendon of the triceps. There are some fibres, however, which extend from the external to the internal tuberosity of the humerus, which are in relation with the synovial membrane in front, and the tendon of the triceps behind.

The *synovial membrane* covers the posterior surface of the anterior ligament: from this it is reflected upon the coronoid cavity, covers the olecranon cavity behind, and is prolonged a little between the tendon of the triceps and the back of the humerus. In this place it is widest and most loose. Below, it forms a prolongation which extends into the radio-cubital articulation, covering the whole inner surface of the annular ligament, and forming a circular cul-de-sac below it.† There is some synovial adipose tissue round the points of reflection, and also at the margin of the olecranon cavity.

Mechanism of the Humero-cubital Articulation.

Extension and flexion, the only motions performed by this joint, are executed by it with remarkable precision and rapidity. The precision of these movements depends, 1. upon the exact fitting of the articular surfaces, no articulation so well deserving the name of a hinge-joint; 2. upon the great extent of the transverse diameter, round which the movements of flexion and extension are performed as round an axis; 3. their rapidity depends chiefly on the smallness of the circle to which the curve of the humeral trochlea belongs.

1. *Flexion.* In this motion, which is very extensive, the raidus and ulna move as a single bone from behind forwards, on the small head and trochlea of the humerus. It should be observed that, in this movement, the obliquity of the trochlea from behind forwards, and from without inwards, throws the fore-arm, when bent, in front of the thorax, and the hand in front of the mouth. This motion is limited by the meeting of the coronoid process with the coronoid cavity. When this motion is carried to the greatest extent, the upper end of the olecranon descends to the level of the lowest part of the trochlea, and is, consequently, below the line which passes through the two tuberosities, or condyles of the humerus. In this motion, the back part of the trochlea and the olecranal fossa are covered only by the tendon of the triceps, so that instruments can readily enter the joint at this place.

2. *Extension.* In this movement the radius and ulna roll backwards upon the humerus. This motion can only be carried so far that the fore-arm and the arm form a right line, for then the upper part of the olecranon comes in contact with the bottom of the olecranal fossa. The anterior ligament and the anterior and middle bundles of the internal lateral ligament are put on the stretch, and thus concur in limiting the movement of extension. There is no appreciable lateral motion of this joint, the exact fitting of the articular surfaces effectually preventing it.

The Radio-cubital Articulations (*figs.* 71 to 75.).

In these articulations the radius and the ulna are united, 1. by their upper ends (*superior radio-cubital articulation*); 2. by their lower ends (*inferior radio-*

* It should be remarked that none of these ligaments of the elbow-joint are attached directly to the radius; but that the fibres which are directed towards this bone join the annular ligament. This arrangement allows the radius to rotate with perfect freedom within its ring, which would have been impossible had the fibres been directly inserted into the bone.

† [According to the common opinion, the articular surfaces of the radius and ulna are of course also covered by the synovial membrane.]

cubital articulation); 3. by the interosseous ligament through a great part of their extent.

Superior Radio-cubital Articulation.

Preparation. Remove with care the anconeus and the supinator brevis, and separate the fore-arm from the arm.

The *articular surfaces* are the edge of the head of the radius, which is of unequal height in different parts, and the lesser sigmoid cavity of the ulna, which is oblong from before backwards, broader in the middle than at the ends, and which forms the bony portion of the *osteo-fibrous ring* in which the head of the radius rolls.

The *means of union* consist of the *annular ligament of the radius* (*e, figs.* 71 and 72.). This ligament is a band forming three fourths of a ring which is completed by the lesser sigmoid cavity of the ulna; it is attached by its two ends to the fore and back part of this cavity. Its internal surface is in contact with the articular border of the head of the radius. The external lateral ligament is attached to its outer surface, and evidently becomes continuous with its posterior half. This arrangement has doubtless given rise to the assertion, that the external lateral ligament is attached to the ulna. Those fibres of the anterior ligament which are directed obliquely downwards and outwards, are also inserted into the annular ligament. All these ligamentous attachments retain the annular ligament in its proper position; when they are divided, it is manifestly retracted towards the neck of the radius, and exposes the articular edge of the bone. The breadth of the annular ligament is from three to four lines, and its upper circumference is wider than the lower, which construction tends to maintain the head of the radius in its situation more accurately. With regard to its structure I would observe, that it is much thicker behind where it receives the insertion of the external lateral ligament, than in front where it may be much more easily ruptured; and I am persuaded that in luxation of the elbow it is not the external lateral ligament which is most commonly torn, but rather the anterior portion of the annular.

The *synovial capsule* is a sort of diverticulum from that of the elbow-joint, which is prolonged upon the inner surface of the annular ligament, and is reflected upwards from its lower margin, so as to form a sort of cul-de-sac below it.

Inferior Radio-cubital Articulation.

Preparation. 1. Remove the muscles on both aspects of the fore-arm; 2. Separate the hand from the fore-arm so as to expose the lower surface of the triangular ligament, or fibro-cartilage; 3. In order to examine the interior of the joint, saw through the middle of the fore-arm; divide the anterior and posterior ligaments; separate the two bones of the fore-arm; cut through the triangular ligament at its insertion into the ulna.

The *articular surfaces* are a small sigmoid cavity on the radius, analogous to that which we have described at the upper end of the ulna, and the external two thirds of the circumference of the head of the ulna. This articulation, therefore, is precisely the reverse of the upper, since in this the ulna furnishes the head, and the radius the sigmoid cavity, whilst a precisely opposite arrangement obtains in the upper joint.

The *means of union* are, 1. some fibres stretched in front and behind the joint, and called anterior (*f, figs.* 71. and 75.) and posterior (*g, figs.* 72. and 74.) ligaments. They form a very imperfect annular ligament. They extend from the anterior and posterior margins of the sigmoid cavity of the radius, to the anterior and posterior surfaces of the styloid process of the ulna.

2. The *triangular ligament*, or rather *cartilage* (*i, figs.* 71. and 73.). This is a triangular lamina of cartilage, the apex of which is fixed into the angle formed by the head and styloid process of the ulna, and its base into the lower edge of the sigmoid cavity of the radius. It is thin at the base and the centre, and thick at the apex and the circumference. It concurs in maintaining the

union of the radius and ulna, and performs the office of those inter-articular cartilages, which we have noticed as peculiar to such joints as are most exposed to shocks and friction; and above all, it restores the level of the inferior radio-cubital surface by filling up the vacancy caused by the projection of the radius below the ulna.

There is a separate *synovial membrane* for this joint (see above *i*, *fig.* 75.), (often called *membrana sacciformis*). It covers the upper surface of the triangular ligament, and the sort of incomplete ring which circumscribes the head of the ulna. It forms very loose folds at the places of reflection, which admit of very extensive rotation.

Middle Radio-cubital Articulation, or Interosseous Ligament.

The *interosseous ligament* (*l*, *figs.* 71, 72.), improperly so called, is an aponeurosis which occupies the interval between the radius and ulna, and which appears to serve principally for the insertion of muscles. It is broader in the middle than at the ends, and does not reach the extremities of the interosseous space, for there is an interval above and below, which serves the purpose of giving passage to nerves and vessels, and also permits more free motion between the two bones. The fibres which compose it are directed obliquely downwards and inwards, *i. e.* from the radius to the ulna. We generally observe on its anterior aspect several bundles running downwards and outwards; the superior and the strongest of these is called the *round ligament*, or the *ligamentous cord of Weitbrecht* (*m*, *fig.* 71.). It extends obliquely downwards and outwards, from the outside of the coronoid process of the ulna to the lower part of the bicipital tuberosity of the radius. Its direction is, therefore, precisely the inverse of that of the fibres of the interosseous ligament.

Mechanism of the Radio-cubital Articulations.

These articulations, like all trochlear joints, only admit of one kind of motion, viz. rotation, which is here called by a peculiar name. Rotation forwards is denominated *pronation*; rotation backwards is called *supination*. We must examine these in both the upper and the lower radio-cubital articulations.

Mechanism of the superior Radio-cubital Articulations.

Pronation. In this movement, the inner part of the head of the radius rolls backwards upon the lesser sigmoid cavity of the ulna, and may be carried so far that the radius may describe half a circle upon its axis. Notwithstanding the obstacles to displacement resulting from the strength of the back part of the annular ligaments, and the presence of the two little hooks, one in front and the other behind the lesser sigmoid cavity of the ulna, and lastly, notwithstanding the advantage produced by the reception of the small head of the humerus in the cup-like cavity of the upper end of the radius, in violent pronation the head of the radius is frequently luxated backwards. Perhaps no dislocation is more common in infancy than the incomplete luxation backwards of the upper end of the radius, on account of the greater looseness of the annular ligament and the less complete reception of the small head of the humerus in the cupula of the radius. The cause occasioning this displacement is forced pronation, so frequent when infants are held by the hand, in attempting to save them from falling.

In *supination* the head of the radius turns upon its axis in a different direction, *i. e.* its inner part glides forwards upon the lesser sigmoid cavity of the ulna. If it be carried too far, dislocation forwards may be the consequence.*

* This displacement is very uncommon, on account of the hook-like projection at the anterior extremity of the sigmoid cavity, and doubtless, also, because forcible supination is very rare. Professor Dugès informs me that he has seen an instance of this dislocation of the radius, and proved its existence by inspection after death.

Mechanism of the inferior Radio-cubital Articulations.

The movements of pronation and supination, at the lower radio-cubital articulation, are produced by a mechanism which is precisely the inverse of the former, for the radius, instead of rotating upon its own axis, turns round the head of the ulna by a movement of circumduction. This difference results partly from the curvature of the radius, and partly from the great transverse diameter of its lower end, which forms the radius of the arc of the circle which it describes round the ulna. In pronation the little sigmoid cavity rolls forwards on the articular edge of the head of the ulna; in supination it glides in the opposite direction, that is, backwards. We see then that, in the lower articulation, a concave surface moves upon a convex, while the contrary takes place at the upper.

The triangular ligament has no effect in limiting these motions; but they are restrained by means of the anterior and posterior ligaments. In forcible pronation these may be broken, and the head of the ulna dislocated backwards; in forcible supination it may be dislocated forwards. It should be remarked that, in cases of luxation of the ulna, the head of this bone does not lacerate the capsule, but the capsule is torn upon it; for, as we shall afterwards see, the ulna is immoveable at the cubito-carpal joint, and takes no share in the partial motions of the fore-arm.

Mechanism of the Radio-cubital Articulations, considered with reference to the Bodies of the two Bones.

In the movement of pronation, the radius crosses the ulna at an acute angle, so that its lower part is carried in front of the ulna, while the upper remains on the outside. The movement of supination consists in the return of the radius to its state of parallelism with the ulna. In pronation, the interosseous ligament is relaxed; in supination, it is stretched: its absence at the upper part of the fore-arm, where its place is supplied by the ligament of Weitbrecht, allows more extensive rotatory movements.*

The existence of the interosseous space is an indispensable condition for the performance of pronation and supination; and therefore every curative plan for the treatment of fractures of the fore-arm which does not provide for the preservation of this space should at once be rejected.

In the explanation we have given of the mechanism of the radio-cubital articulations, the ulna has been considered as an immoveable axis round which the radius executes below certain movements of circumduction; but many authors have maintained the opinion that the ulna also takes part in these motions. Without discussing the different theories which have been successively proposed on this subject, we shall mention an experiment which is at once decisive of the question. If all the articulations of the arm be exposed from the shoulder to the hand, and the humerus be immoveably fixed in a vice, it will be seen that, when the fore-arm is pronated or supinated, the radius moves upon the ulna, which remains altogether undisturbed; and, also, that any lateral motion of the ulna is absolutely impossible from its perfect jointing with the humerus at the elbow. When the humerus is not completely fixed, it also rotates in conjunction with the bones of the fore-arm.

Lastly, it should be observed that, when the radius is rotated during semiflexion of the fore-arm, the motion is accompanied by slight degrees of flexion and extension at the elbow-joint.

* If the interosseous ligament, the fibres of which pass downwards from the radius to the ulna, had been prolonged to the upper part of the interosseous space, it would have much impeded the motions of supination, by limiting the movements of the bicipital tuberosity, into which one of the supinator muscles of the fore-arm, viz. the biceps, is inserted; but the round ligament being inserted below the bicipital tuberosity, and passing downwards from the ulna to the radius, can have no effect in limiting the extent of rotation.

Radio-carpal Articulation (*figs.* 73. to 75.).

Preparation. Carefully remove the fibrous sheaths of the flexor and extensor tendons.

This articulation belongs to the class of *condylarthroses*

The articular surfaces (*fig.* 73.) are those of the scaphoid, the semilunar, and the cuneiform, which together form a condyle, oblong transversely, and covered by articular cartilages, which are prolonged further on the posterior than on the anterior aspect of the bones, and the transversely oblong concave, articular surface, formed by the lower ends of the radius and ulna. The radius which forms by itself two thirds of the surface corresponds to the scaphoid and semilunar, and presents an antero-posterior ridge, and a slight contraction from before backwards, opposite the interval between these two bones. The ulna corresponds to the cuneiform bone, with the intervention of an inter-articular cartilage, viz. the triangular cartilage already described, which performs the part both of a ligament and an inter-articular cartilage. The concave surface presented by the lower part of the fore-arm is completed at the sides by the styloid processes of the radius and ulna.

Means of union. There are two lateral, three anterior, and some posterior ligaments.

The *external lateral ligament* (*a*, *figs.* 73, 74, 75.), stretches from the summit of the styloid process of the radius to the outer part of the scaphoid, where it is inserted by a broad attachment immediately on the outside of the radial articular surface of that bone. The anterior bundles of this ligament are the strongest.

The *internal lateral ligament* (*b*, *figs.* 73, 74, 75.), is very slight; it commences at the summit of the styloid process of the ulna, and divides into two fasciculi, one of which is attached to the pisiform, the other to the cuneiform bone.

The *anterior ligaments* (*c*, *fig.* 75.) are three in number, and all extend from the radius to the bones of the carpus. The *external anterior ligament* arises from the styloid process of the radius, and is lost among the anterior ligaments of the carpus. The *middle anterior ligament*, straight and short, arises from the anterior edge of the lower end of the radius near the styloid process, and passes somewhat obliquely inwards to the anterior extremity of the os semilunare. The *internal anterior ligament* also commences at the anterior edge of the radius, but to the inside of the preceding, and extends to the anterior extremity of the os semilunare. This ligament is very strong, and is continuous with the triangular cartilage.

The *posterior ligaments* (*d*, *fig.* 74.) are much weaker than the preceding; they are stretched obliquely from the posterior border of the articular surface of the radius, to the posterior extremity of the cuneiform and semilunar bones. The fasciculus for the cuneiform bone is very thick.

With regard to the anterior and posterior ligaments of the wrist-joint, we may remark, that they all come exclusively from the radius, and closely unite the lower end of this bone to the first range of the carpus, and consequently to the hand.

The *synovial membrane* (see *fig.* 73.) is loose behind, where it is only partially covered by the ligaments we have described; throughout the whole of the remaining circumference of the joint it is strengthened by scattered ligamentous fibres, which some anatomists have described as a capsular ligament. This synovial membrane sometimes communicates with that of the lower radio-cubital articulation, by an opening at the place of union of the triangular cartilage with the lower edge of the sigmoid cavity of the radius. It also sometimes communicates with the general synovial membrane of the carpus, by the interosseous spaces which separate the bones of the first carpal row.

Besides the means of union which we have described, the flexor tendons in front, and the extensor tendons behind, should be noticed, as serving to increase the strength of the joint.

Mechanism of the Radio-carpal Articulation.

This articulation belongs to the condyloid class, and has, therefore, four motions, viz. flexion, extension, abduction, and adduction, and by passing from one of these to the other it can perform circumduction.

1. *Flexion.* In this motion the condyle formed by the first row of the carpus glides backwards upon the lower end of the fore-arm. The posterior ligaments and the extensor tendons are put on the stretch. When the movement of flexion is carried too far, luxation may take place by laceration of the posterior ligaments, and then the lower end of the two bones of the fore-arm pass in front of the articular surface of the bones of the first row of the carpus. It should however be observed, that the possibility of dislocation of this joint has been doubted.

2. In *extension*, the condyle formed by the carpus rolls forwards upon the lower end of the fore-arm; and as the articular surface of the carpus reaches further on the back than in front, it follows that extension may be carried further than flexion: it is limited by the strong anterior ligaments, and also by the lateral ligaments, which, as is generally observed, are attached nearer to the side of flexion, than to that of extension.

It should also be remarked, that extension is the easiest motion of the hand upon the fore-arm: this may be readily understood from the great power which the hand possesses when it forms a right angle behind with the fore-arm.*

3. In *abduction* the condyle formed by the carpus rolls in the direction of its length, *i. e.* transversely and from without inwards, while the radial edge of the hand is inclined towards the radial edge of the fore-arm: this motion is limited by the mutual meeting of the styloid process of the radius, and the external process of the scaphoid.

4. In *adduction* the ulnar edge of the hand is bent towards the ulnar edge of the fore-arm; the motion is limited by the meeting of the summit of the styloid process of the ulna and the cuneiform bone, and also by the tension of the external lateral ligament.

It may be easily conceived, that in the lateral movements, which are performed in the direction of the long diameter of the articular surfaces, dislocation must be very difficult, and that when it does occur it must be incomplete.

The *movement of circumduction* is nothing more than a succession of the different motions which have been already pointed out. The hand describes a cone, of greater extent behind, that is, in the direction of extension, than in front, or in the direction of flexion. It is also still more restricted in adduction and abduction.

Articulations of the Carpus (*figs.* 73 to 75.).

These articulations comprise, 1. the articulations of the bones of each row together; and 2. the articulations of the two rows.

Articulations of the Bones of each Row.

Preparation. 1. Remove the extensor and the flexor tendons; 2. Separate the hand from the fore-arm, then the first row from the second, and lastly the bones of both rows from each other, examining their means of union, before completing the separation.

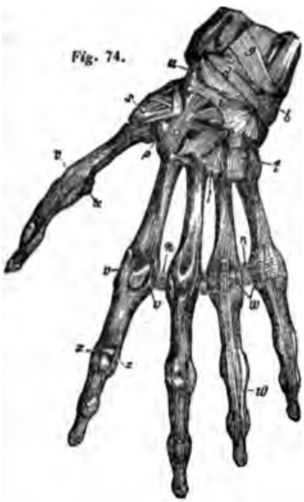
Articular surfaces. The articulations of the bones of each row are *amphiarthroses*, and consequently present one part continuous, and another contiguous. The bones of the first row correspond to each other by oblique surfaces, those of the second row by vertical and more extensive surfaces.

Means of union. Two classes of ligaments belong to these joints: the one

* We should observe that it is almost impossible to separate the mechanism of the carpal articulations from that of the radio-carpal joint; the latter is noticed here by itself only in order to conform with the anatomical divisions.

1. *Articulations of the Carpal Ends of the Metacarpal Bones.*

These are *symphyses* or *amphi-arthroses*. The *articular surfaces* (see *fig.* 73.) occupy the sides of the carpal ends of the metacarpal bones, and are partly contiguous and partly continuous. The contiguous portion consists of a facette covered with cartilage, and is, in fact, an extension of the surface that articulates with the carpus. The part intended to become continuous is rough.

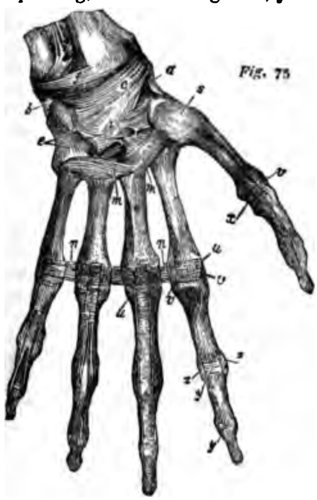


The *means of union* are the *interosseous*, the *dorsal*, and the *palmar ligaments*. The interosseous ligaments (*f f*, *fig.* 73.) are short, close, and very strong bundles of fibres, interposed between the rough portions of the lateral facettes of two neighbouring metacarpal bones. They constitute the principal means of uniting these bones, as may be seen by attempting to separate them after dividing the dorsal and palmar ligaments.

The *dorsal* (*l*, *fig.* 74.) and *palmar ligaments* (*m*, *fig.* 75.) consist of fibrous bundles, stretched transversely from one metacarpal bone to another. The palmar ligaments are much larger than the dorsal.

2. *Articulation of the Digital Ends of the Metacarpal Bones.*

Although the digital extremities of the metacarpal bones are not, properly speaking, articulated together, yet as they are contiguous, and move upon each other, their surfaces are covered by a synovial membrane, which facilitates their movements; moreover, a *palmar ligament* (*n*, *figs.* 74, 75.) is stretched transversely in front of these extremities, and unites them loosely together. This ligament (called also *transverse*) is common to the four last metacarpal bones, but it does not reach the metacarpal bone of the thumb. It may be considered as formed by the union of all the anterior ligaments of the metacarpo-phalangal articulations, which are rendered continuous by small bands stretched from one to the other. In order to expose this ligament, it is sufficient to open the fibrous sheaths of the flexor tendons of the fingers, and to remove the small lumbricales muscles, together with the nerves and vessels of the fingers.



We may consider the *interosseous aponeurosity* as representing, in respect to the shafts of the metacarpal bones, the aponeurosis called the interosseous ligament in the fore-arm.

The interosseous muscles, as we shall afterwards see, complete the means of union of the metacarpal bones.

Carpo-Metacarpal Articulations.

The *articular surfaces* are the inferior facettes on the bones of the second row of the carpus; and the facettes on the upper ends of the metacarpal bones. We may consider all the carpo-metacarpal articulations as forming only one joint with a broken surface. The articulation of the trapezium with the metacarpal bone of the thumb, and that of the fifth metacarpal bone with the os unciforme, require each a special description.

Articulations of the Second, Third, and Fourth Metacarpal Bones with the Carpus.

Articular surfaces (see *fig.* 73.). The articulation of the second, third, and fourth metacarpal bones with the carpus, presents a sinuous line. Proceeding from within outwards, the fourth and third metacarpal bones form a regular curve, with the concavity looking upwards; but the second, which unites by three facettes with the trapezium, the trapezoid, and os magnum, presents an angular surface. The second metacarpal bone is jointed by its transversely concave surface, with a facette on the trapezoid, which is concave, but in the opposite direction, and by two lateral facettes with the os magnum and the trapezium, so that it enters, as it were, into the carpus by two angular projections, which are received into the intervals between the three bones with which it is articulated. From this it follows, that the carpo-metacarpal articulations present not only concave and convex surfaces, favourable to mobility, but also angular surfaces that evince the immobility of these joints.

Means of union. Some ligaments, distinguished as *dorsal* and *palmar*, both very strong, short, and compact, retain the articular surfaces as immoveably in contact, as if the joints were symphyses.

The *dorsal ligaments* are much stronger than the palmar, and are composed of several layers, the deepest being the shortest. There are three dorsal ligaments for the second metacarpal bone; a *median* (*o*, *fig.* 74.), stretched to it from the trapezoid bone; an *external* (*p*) which comes from the trapezium, and covers the insertion of the extensor carpi radialis longior; and an *internal*, arising from the os magnum: the first of these is vertical, the last two are oblique. There are two dorsal ligaments in the articulation of the third metacarpal bone; a *vertical*, which comes from the os magnum, and an *oblique* (*r*), from the os unciforme.

In the articulation of the fourth metacarpal bone there is one dorsal ligament, longer and looser than the preceding.

The *palmar ligaments* are much less marked than the preceding; contrasting thus with the palmar ligaments of the carpus. There is none for the second metacarpal bone; the tendon of the flexor carpi radialis appears to supply the place of this ligament. There are three ligaments for the third metacarpal bone; an *external*, which comes from the trapezium; a *middle*, proceeding from the os magnum; and an *internal*, from the os unciforme. Lastly, for the articulation of the fourth metacarpal bone, there is one palmar ligament from the os unciforme.

The *synovial membrane* (see *fig.* 73.) of the carpo-metacarpal articulations is a continuation of the synovial membrane of the carpus, and is prolonged between the upper ends of the metacarpal bones; and as the synovial membrane of the carpus communicates also with the radio-carpal joint, it can be conceived what ravages may be produced by inflammation attacking any one of these parts. I must here point out an *interosseous*, or *lateral ligament* (*l*, *fig.* 73.), which arises from the os magnum, and slightly, also, from the os unciforme, and is attached to the inner side of the third metacarpal bone. It almost completely isolates the articulations of the last two metacarpal bones. This ligament being attached to the third metacarpal bone, which is already provided

with very strong ligaments, increases in a remarkable manner the strength of the joint.

Carpo-metacarpal articulation of the thumb. This joint (*m*, *fig.* 73.) which is very distinct and completely separated from all the others, is remarkable, also, for the arrangement of the articular surfaces. There is a mutual jointing between the trapezium, which is concave transversely, and convex from behind forwards; and the first metacarpal bone, which is concave and convex in precisely opposite directions. It is the type of all articulations by *mutual reception.*

The *means of union* consist of a *capsular ligament* (*s*, *figs.* 74 and 75.), imperfect on the outside, where its place is occupied occasionally by the tendon of the abductor longus pollicis (extensor ossis metacarpi pollicis): it is much thicker behind than in front, and is sufficiently loose to permit extensive motions in all directions. There is a separate *synovial membrane* for this joint, which is remarkable in respect of its relations; viz. 1. behind, with the extensor muscles of the thumb; 2. on the outside, with the expanded tendon of the abductor pollicis; 3. on the inside, with the interosseous muscles and the radial artery, where that vessel penetrates into the palm of the hand, to form the deep palmar arch; and 4. in front, with the muscles of the ball of the thumb.

Carpo-metacarpal articulation of the fifth metacarpal bone (see *fig.* 73.). The articulation of the fifth metacarpal bone with the os unciforme is, in many respects, analogous to the preceding; for there is here, also, a sort of mutual reception between their corresponding articular surfaces. There is, also, a kind of capsular ligament (*t*, *fig.* 74.), very strong in front and thin behind, and incomplete on the outside, on account of the presence of the fourth metacarpal bone: it is rather loose, and maintains the relation of the articular surfaces. The tendon of the extensor carpi ulnaris strengthens this joint behind, in the same manner as the tendon of the long abductor of the thumb strengthens the articulation of the trapezium and the first metacarpal bone.

The *synovial membrane* of this joint belongs also to the fourth metacarpal bone. The fourth and fifth metacarpal bones may, indeed, be strictly considered as forming only one joint, and the lateral interosseous ligament as completing the capsular ligament. On the other hand, the second and third metacarpal bones form a very distinct articulation with the os magnum, the trapezoid, and a small facette upon the trapezium; lastly, there is another joint peculiar to the first metacarpal bone and the trapezium. There are thus three distinct joints (see *fig.* 73.) in the carpo-metacarpal articulation, in one of which the articular surfaces are simple, whilst, in the two others, they are broken.

Mechanism of the Carpo-metacarpal Articulations.

The mechanism of the carpo-metacarpal articulations should be studied, both as regards strength and mobility.

1. *With regard to strength*, the metacarpal bones mutually support each other, and resist in common the action of external agents: they can only be broken, therefore, by violence sufficient to fracture several at the same time. In order that any one should be broken alone, the violence must be applied directly to it. In this manner I have seen the third metacarpal bone fractured by the stick of a rocket.

The great strength of the metacarpus depends not only on the simultaneous resistance of its component parts, but also on the intervening articulations, each of which becomes the seat of a certain expenditure of force; for part of this being employed in moving the articular surfaces upon each other, is necessarily lost as far as its direct transmission is concerned.

With regard to mobility, the articulations are only possessed of slight gliding motions, on account of the angular disposition of the articular facettes, the

sinuosity of the common articular line, and the strength and shortness of both the external and the interosseous ligaments. At the same time, the mobility of all the metacarpal bones is not equal. Thus, the articulation of the trapezium with the first metacarpal bone holds the first rank ; it is in some degree different from the others in this respect as well as in position, and merits particular description. The articulation of the fifth metacarpal bone holds the second place, and that of the fourth the third. The articulations of the second and third metacarpal bones are as immoveable as symphyses.

Mechanism of the articulation of the trapezium and the first metacarpal bone. From the mutual reception of the articular surfaces this articulation permits four motions, viz. flexion, extension, abduction and adduction, and as a consequence of these, circumduction.

Flexion is not performed directly, but obliquely inwards and forwards. This oblique motion produces the *movement of opposition* which characterises the hand: it is very extensive, and when carried too far may produce luxation backwards, with the greater facility because the capsular ligament is very thin in that direction. *Extension* may be carried so far that the first metacarpal bone may form a right angle with the radius. It is conceivable that luxation forwards might be produced by this motion; but there are very few causes that would tend to increase extension to such a degree, and, moreover, the anterior part of the capsular ligament is extremely strong, so that no example of this luxation has ever been recorded.

Abduction is very extensive: when carried beyond a certain point it may give rise to dislocation inwards, for the trapezium, being situated on a plane anterior to the root of the metacarpus, the neighbouring metacarpal bones offer no obstacle to such a displacement.

Lastly, direct *adduction* is limited by the meeting with the second metacarpal bone.

Mechanism of the articulation of the fifth metacarpal bone with the cuneiform. This articulation in some degree resembles the preceding, and, like the last, it would be liable to dislocation, were it not for its intimate connections with the other metacarpal bones, so that the same cause that would tend to displace the fifth metacarpal bone would also tend to displace the fourth.

Articulations of the Fingers (*figs.* 74 and 75.).

These comprise 1. the articulations of the fingers with the metacarpal bones; 2. the articulations of the phalanges together.

Metacarpo-phalangal Articulations.

These belong to the class of condyloid articulations.

The *articular surfaces* in each are formed by the head of the metacarpal bone, flattened from side to side, increasing in breadth from the dorsal to the palmar aspect, and prolonged much further in the latter direction, where it presents the trace of a division into two condyles; and by the shallow *glenoid cavity* of the first phalanx, which is transversely oblong, and consequently has its long diameter at right angles to that of the head of the metacarpal bone, which is oblong from before backwards. We see, then, that an articular head, elongated from before backwards, is adapted to a transversely oblong cavity. This arrangement favours the movements of flexion and extension, as well as the lateral motions, which are as extensive as they would have been, had all the diameters of the articular surfaces been equal to those which are actually the longest.

It is on account of the lateral flattening of the heads of the metacarpal bones, that in amputations at these joints surgeons make choice of lateral in preference to antero-posterior flaps.

Means of union. On account of the disproportion just noticed as existing between the articular surfaces of this joint, the glenoid cavity of the first phalanx not being equal to more than one half of the articular surface on the metacarpal bone, that cavity is provided with a ligament, called the *anterior ligament* (*u*, *fig.* 75.) by Bichat, but which I would denominate the *glenoid ligament*, and which serves principally to complete the cavity of reception. This ligament is situated on the palmar aspect of the joint; it is very thick, and as compact as cartilage; it is formed by intersecting fibres, and is continuous by its edges, partly with the sheaths of the flexor tendons, partly with the transverse metacarpal ligaments, but chiefly with the lateral ligaments of the joint. It is grooved in front to correspond with the flexor tendons, and concave behind to fit the convexity of the head of the metacarpal bone; it is firmly fixed by its lower edge to the anterior margin of the phalangal articular surfaces, of which it appears to form the continuation; its upper edge is free, or rather very loosely connected by some ligamentous fibres to the inequalities surmounting the head of the metacarpal bone in front, and it is so accurately adapted to the contracted neck which supports the head of this bone, that, by this arrangement alone, the articular surfaces are maintained in contact. But there are also two very strong *lateral ligaments* (*v*, *figs.* 73. and 75.), an internal and an external. These ligaments are inserted, not into the lateral depression existing on each side of the head of the metacarpal bones, but into the tubercles behind this depression; the ligaments therefore are directed obliquely downwards and forwards, under the form of flattened bands, which become broader, and terminate in the glenoid ligament on the sides of the phalanx.

There is no dorsal ligament properly so called; its place is evidently supplied by the corresponding extensor tendon (*w*, *fig.* 74.). It is not uncommon to see a small fibrous band extending from the anterior surface of the tendon, and attached to the metacarpal end of the first phalanx.

The *synovial capsule* is extremely loose, especially on the aspect of extension: it does not adhere to the tendon, but is folded upon itself during extension, and is stretched during flexion: it lines the inner surface of the lateral ligaments, and is reflected upon the articular cartilages.

Metacarpal-phalangal articulation of the thumb. Two sesamoid bones (*x*, *figs.* 73. and 75.), are annexed to this articulation in front, and are constantly found in the glenoid ligament; they afford insertion to the lateral ligaments and to all the short muscles of the thumb.

If we examine these articulations in connection, we shall find that they are disposed in a curved line, with the convexity looking downwards. This curvature is slightly interrupted at the articulation of the fourth metacarpal bone, which is not on a level with those of the index and the middle fingers.

Mechanism of the Metacarpo-phalangal Articulations.

We shall take as an example the metacarpo-phalangal articulation of the thumb. From the arrangement of the articular surfaces, it is evident that this articulation can execute movements in four principal directions, and consequently those of circumduction also. From a simple inspection of the surfaces it might be inferred that the movement of flexion must be very extensive, whilst that of extension (or flexion backwards) and the lateral motions of abduction and adduction must be exceedingly limited. The arrangement of the ligaments amply confirms these suppositions.

In *flexion* the first phalanx glides forwards upon the head of the corresponding metacarpal bone; the extensor tendon and the back of the synovial capsule are stretched by the projecting head of this bone: the posterior fibres of the lateral ligaments are also stretched; they limit the movement of flexion, allowing it only to proceed so far that the phalanx forms a right angle with the metacarpal bone. Lastly, flexion can be carried somewhat further by the thumb, the ring, and the little fingers than by the others. In *extension* the

phalanx glides backwards upon the head of the metacarpal bone supporting it: this head corresponds almost entirely with the glenoid ligament. The posterior fibres of the lateral ligaments are relaxed, and the anterior stretched. The motion is evidently limited by these anterior fibres and by the glenoid ligament, the upper edge of which forms with them a narrow ring that surrounds the neck of the corresponding metacarpal bone.

According to the relative size of this ring, and the comparative looseness of the glenoid ligament, will the movement of extension be more or less considerable. In all persons it may be carried so far, as to form an obtuse angle behind; in some, until a right angle is formed; and in a few, even so far as to produce an incomplete luxation, reducible by the slightest muscular effort. If extension be carried beyond these limits (for which, however, considerable violence is necessary) the head of the metacarpal bone escapes from the kind of collar, formed by the superior border of the glenoid ligaments, and the anterior fibres of the lateral ligaments, sometimes by extensively lacerating it, but at others only by stretching it very much; in both cases the first phalanx is dislocated backwards, or the metacarpal bone forwards. When the collar is not torn, reduction is almost impossible, because the glenoid ligament is always interposed between the articular surfaces.

Adduction and *abduction* consist of simple lateral glidings, limited by the meeting of the other fingers.

Articulations of the Phalanges of the Fingers.

These are pulley-like joints, or perfect angular ginglymi. There are two articulations of this kind in each finger, but only one in the thumb.

Articular surfaces. The lower end of the first phalanx, flattened from before backwards, presents a trochlea, broader on the palmar than on the dorsal aspect, and prolonged much further in front than behind. The trochlea of the phalanx resembles the lower end of the femur, with this difference, that its two condyles are not separated from each other. The upper end of the second phalanx, also flattened from before backwards, presents two small glenoid cavities separated by an antero-posterior ridge. The ridge corresponds to the groove of the pulley, and the glenoid cavities to the two condyles.

Means of union. 1. A *glenoid ligament* (*y*, *fig.* 74.), exactly resembling that which exists in the metacarpo-phalangal articulations, and performing the same office of deepening the glenoid cavity, which by itself only imperfectly receives the pulley of the first phalanx. 2. Two *lateral ligaments*, an *internal* (*z*), and an *external* (*z'*), arranged precisely in the same manner as the lateral ligaments of the metacarpo-phalangal articulations. They are attached to tubercles situated behind the lateral depressions, on the lower end of the first phalanx, and pass obliquely forwards, to be inserted both into the glenoid ligament and the second phalanx. There is no posterior ligament, its place being supplied by the extensor tendon. This tendon is disposed in a peculiar manner: in general, it gives off a prolongation (*w*) from its anterior aspect, which is inserted into the upper end of the second phalanx, so that this bone presents a somewhat similar arrangement behind, as it does in front with the flexor tendon.

The *synovial capsule* is precisely similar to that of the metacarpo-phalangal joints. The foregoing description applies equally well to the articulation of the second with the third phalanx. There is often a sesamoid bone in the substance of the glenoid ligament of the two phalangal joints of the thumb.

Mechanism of the Phalanges.

The fingers are essentially the organs of prehension and of touch. In the mechanism of touch the fingers are moved over the surfaces of bodies, and are moulded upon even their slightest inequalities, sometimes acting together, sometimes separately, seizing and moving between them, as between the blades of sentient forceps, even the most delicate objects. For the performance of this

function great mobility must be conjoined with great precision of movement. On the other hand, for the purpose of seizing bodies, of retaining, repulsing, or breaking them, as well as of acting as the means of attack and defence, considerable power is required; all which qualities are united in the mechanism of the hand. Observe the number of the fingers and their complete isolation, so that they can act either together or separately, and even in opposite directions. Notice the number of the phalanges, their successive decrease in size, and the facility with which they can be separated or made to approach each other, so as to be applied around spherical bodies. Note also the inequality of the fingers in length and power, enabling each to act a determinate part in prehension; and above all, remark the shortness of the thumb, which only reaches the base of the first phalanx of the index finger; but which, placed as it is upon a plane anterior to the rest, and endowed with a greater degree of mobility, can be opposed to all the fingers together, to each finger separately, and to every phalanx of each, thus constituting the principal blade of the sentient forceps represented by the hand; for, being more strongly constructed, and provided with more powerful muscles than the other fingers, it in some degree counterbalances them all.

Mechanism of the Phalangal Articulations.

From the shape of the articular surfaces, which form a miniature representation of the knee, it is evident that the only motions of which these joints are capable are flexion and extension. The *flexion* of the second upon the first phalanx is as extensive as it could possibly be, for it is only limited by the meeting of the anterior surfaces of these bones. The amount of *flexion* of the third phalanx upon the second is less considerable. The *extension* of the second phalanx upon the first, and that of the third upon the second, are limited, as in the metacarpo-phalangal joints, by the anterior glenoid and the lateral ligaments. This motion of the phalanges is extremely slight; I have never seen them carried further back than to form a straight line.

From what has been observed it follows that, as regards its movements, each finger represents a shortened or miniature limb; that, at its articulation with the metacarpus, it is capable of motions in every direction, and also of circumduction; that, from the joints between the phalanges, it is endowed with the power of strong, extensive, and accurate flexion; and that, from the double bending of the second upon the first, and the third upon the second phalanges, the fingers represent a true hook for seizing and clinging to external objects.

ARTICULATIONS OF THE INFERIOR OR ABDOMINAL EXTREMITIES.

Articulations of the pelvis. — Coxo-femoral. — Knee-joint. — Peroneo-tibial. — Ankle-joint. — Of the tarsus. — Tarso-metatarsal. — Of the toes.

Articulations of the Pelvis (*figs.* 76, 77.).

The articulations of the pelvis are, 1. the sacro-iliac symphysis; 2. the symphysis pubis; and 3. the sacro-coccygeal articulation. The last has been already described with the other articulations of the vertebral column.

Sacro-iliac Symphysis.

Preparation. 1. Detach the pelvis from the rest of the trunk; 2. saw through the horizontal ramus and arch of the pubes at the distance of about eighteen lines on each side of the symphysis; 3. dislocate the os innominatum of one side; 4. dissect the anterior ligaments of the sacro-iliac symphysis upon the other; 5. then make a horizontal section of that articulation, dividing it into an upper and a lower half.

The sacro-iliac articulation belongs to the class of symphyses or amphi-arthroses.

The *articular surfaces* are formed on the sacrum and os innominatum, and are partly contiguous and partly continuous. The contiguous surfaces of these two bones are anterior to the others, and are shaped like an ear, with the convex edge turned forwards; hence they are called the auricular surfaces. The parts which are rendered continuous by means of ligamentous fibres consist of the entire space comprised between the auricular portion and the posterior border of the os innominatum, and of all the lateral surface of the sacrum not occupied by the auricular facette. The continuous portions are both marked with very rugged eminences and depressions. These articular surfaces are also remarkable from being sinuous and alternately concave and convex, and from their presenting a well-marked obliquity in two directions, viz. from above downwards, and from before backwards and inwards, so that the sacrum is, as it were, wedged between the ossa innominata both in a vertical and an antero-posterior direction.

Means of union. The auricular surfaces are covered with cartilage, which is thicker upon the sacrum than on the os innominatum, and is remarkable for the roughness of its surface, which contrasts with the smooth appearance of other articular cartilages. There is a distinct synovial membrane in this joint in the infant and pregnant female, but it can scarcely be detected in the adult and the aged. The ligaments are, 1. an *anterior sacro-iliac ligament* (*b*, *figs.* 76, 77.) — a very thin layer which passes in front of this articulation, and composed of fibres stretched transversely from the sacrum to the ilium. 2. A *superior sacro-iliac ligament* (4, *fig.* 52.) — a very thick bundle, extending transversely from the base of the sacrum to the contiguous portion of the ilium. 3. An *interosseous ligament*, which forms the strongest bond of union in this joint, composed of a great number of ligamentous fibres, stretched horizontally from the ilium to the sacrum, crossing each other, and filling up almost the whole of the deep excavation comprised between the two bones; these fibres leave small intervals between them which are occupied by fat, and traversed by numerous small veins. One of these bundles merits a special description: it consists of a long and strong band extending almost vertically from the posterior superior spinous process of the ilium to a thick tubercle on the third sacral vertebra; it may be called the *posterior vertical sacro-iliac ligament.* 4. The *ilio-lumbar ligament* (*c*, *figs.* 76, 77.) may be considered as belonging to this joint; it extends from the summit of the transverse process of the fifth lumbar vertebra to the thickest part of the crest of the ilium, that is, to the enlargement situated about two inches in front of the posterior superior iliac spine. It is a thick and very strong triangular bundle.

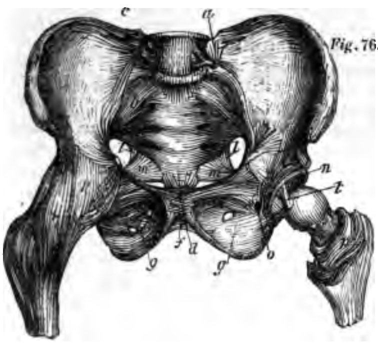


Fig. 76.

Symphysis Pubis.

Preparation. This requires no special directions: only, in order to become acquainted with the respective extent of the contiguous and continuous portions, it is necessary to make a horizontal section, and also a vertical one from before backwards.

The *articular surfaces* (*e*, *fig.* 77.) are oval, having their longest diameters directed vertically; they are flat and obliquely cut from behind forwards and

outwards. They are therefore separated by a triangular interval, the base of which is directed forwards, and the apex backwards. We should observe concerning this articulation, that there are many varieties in the respective extent of the contiguous and continuous portions of the articular surfaces. Sometimes they are almost wholly continuous; at other times, on the contrary, they are nearly altogether contiguous. I have observed this latter disposition in a very remarkable degree in the symphysis of a young woman who died in the sixth month of pregnancy.

The *means of union* are the following:—1. An *anterior pubic ligament* (*d*, *fig.* 76.)—a very thin fibrous layer, the posterior portion of which is blended with the interosseous ligament: it is composed of fibres extending from the spine of each os pubis obliquely to the anterior surface of the opposite pubic bone; those from the left side pass in front of those from the right. 2. A *posterior pubic ligament*, extremely thin, and covering the prominence formed by the ossa pubis behind, at the place of their articulation. This prominence, which is very marked in old subjects, seems to be produced by a jutting out of the posterior table of the bone backwards, apparently caused by the pressure of one articular surface upon the other; these surfaces being, as we have described, in contact behind, but separate in front. In a female who died of peritonitis soon after delivery, I found this posterior prominence of the pubes forming a sort of spine of some lines in diameter from before backwards. 3. A *superior pubic ligament* (*e*, *fig.* 76.), very thick, and continuous on each side with a fibrous cord, that covers the upper edge of the os pubis, and effaces its irregularities. 4. An *inferior pubic* or *triangular ligament* (*f*, *fig.* 76.), which is exceedingly strong; it forms a continuation of the anterior and interosseous ligaments, and is composed of interlacing fibres: this ligament renders the angle formed by the ossa pubis obtuse, and gives to the arch of the pubes that regular curve presented by it to the head of the fœtus during labour. 5. An *interosseous ligament* (*e*, *fig.* 77.); which occupies the whole non-contiguous portion of the articular surfaces, and varies greatly in thickness in different individuals. This ligament forms the principal means of union between the bones of the pubes, and is composed of fibres, which cross each other like those of the intervertebral substances.

Of the Sub-pubic or Obturator Membrane, and the Sacro-sciatic Ligament.

We include the description of the obturator and sacro-sciatic ligaments in the account of the articulations of the pelvis, simply remarking that they can scarcely be considered true ligaments, but rather aponeuroses, which serve to complete the parietes of the pelvis, without contributing any thing to the strength of its articulations. Perhaps they are also useful during the progress of labour, by diminishing the pressure of the soft parts of the mother between the head of the child and the bones of the pelvis.

Sub-pubic or *obturator membrane* (*g*, *figs.* 76, 77.). This membrane closes the obturator (sub-pubic) foramen excepting at its upper part, where we find a notch, by which the groove for the obturator vessels and nerves is converted into a canal. The external half of its circumference is attached to the corresponding margin of the obturator foramen, and the internal half to the posterior surface of the ascending ramus of the ischium; its two surfaces give attachment to the obturator muscles. It is composed of aponeurotic bundles interlaced in every direction.

Sacro-sciatic ligaments. These are divided into the *great* and the *small*: we apply the term ligaments to them rather on account of their fasciculated shape than from their use, which scarcely has reference to the union of the bones of the pelvis.

The *great sacro-sciatic ligament* (*l*, *figs.* 76, 77.) arises from a ridge situated on the internal lip of the tuberosity of the ischium, and also from the ascending ramus of the same bone, by a curved margin of considerable extent, having its concavity directed upwards, which, with the inner surface of the tuberosity of the bone, forms a groove for the protection of the internal pudic vessels and nerves. Immediately after its origin, from its fibres being collected

together, it becomes very narrow and thick, and is directed upwards and inwards; it then expands considerably, and is inserted into the edges of the sacrum and coccyx, and even slightly into the posterior extremity of the crest of the ilium. Its upper edge is continuous with the aponeurosis extending over the pyriformis muscle. It is covered by the gluteus maximus, to which it affords insertions, and is situated posteriorly to the small sacro-sciatic ligament.

Fig. 77.

The *small sacro-sciatic ligament* (*m*, *figs.* 76, 77.), placed in front of the preceding, and extremely thin, arises from the summit of the spine of the ischium, passes inwards, and becoming thinner, is lost upon the anterior surface of the great sacro-sciatic ligament. The two sacro-sciatic ligaments divide the great sacro-sciatic notch into two distinct foramina: the upper (*n*, *fig.* 77.) is very large, and shaped like a triangle with the angles rounded off, and is in a great measure filled up by the coccygeus and pyriformis muscles; it gives passage also to the great and small sciatic nerves, to the ischiatic vessels and to the gluteal and internal pudic vessels and nerves, and to a large quantity of cellular tissue. That form of hernia which is called *sciatic* takes place through this foramen. The lower (*o*, *fig.* 77.) is much smaller it is situated between the spine and tuberosity of the ischium, and gives passage to the obturator internus muscle, and to the internal pudic vessels and nerves.

Mechanism of the Pelvis.

The mechanism of the pelvis should be regarded in four distinct points of view: — 1. as affording protection to the contained viscera; 2. in relation to the part which it performs in the mechanism of standing and progression; 3. in connection with the phenomena of parturition; and 4. in reference to the motions which take place at its articulations with other bones, and those between its own component parts.

1. *Mechanism of the pelvis considered as a protecting structure.* The following are the conditions in the structure of the pelvis, having reference to its office as a protector of the contained viscera: —1. behind; the presence of the sacrum, which is itself protected, as well as the nerves that pass through it, by the great prominence of the posterior iliac tuberosities which project considerably beyond it; 2. on the sides, by the crest of the ilium, and the prominence of the trochanters, which so often preserve the pelvis from external violence; 3. in front, the means of protection are much less efficacious, in consequence of the vast notch which is situated in this region.

The partial absence of the bony parietes in front has reference to the great variations in size which the viscera of the pelvis can undergo, and which would have been incompatible with the existence of an osseous cincture, incapable of dilatation. The absence of bony walls in the situation of the three great notches, presented by the outlet of the pelvis, is also unfavourable to its solidity; but it has many other important uses, particularly in the mechanism of labour. The pelvis, especially at its upper part, where it is most exposed to injury, is enabled to resist external violence by virtue of its vaulted construction. Part of the impulse also is lost in producing the slight degree of gliding motion permitted at the symphysis pubis. Where, however, the power of resistance possessed by the pelvis is overcome, it will be seen at once that the parts most liable to fracture are the ascending rami of the ischia at their junction with the descending rami of the ossa pubis.

2. *Mechanism of the pelvis with regard to standing and progression.* The part

performed by the pelvis in *standing* is connected with the transmission of the weight of the trunk to the lower extremities; this is effected by means of the sacrum, which rests upon the ossa innominata. We should add, that a small portion of the weight is directly transmitted to the femora by the iliac bones, which support the viscera of the abdomen; and in regard to this I would remark, that the breadth and separation of the iliac fossæ in man, as compared with other animals, have an evident relation to his erect posture.

The following arrangements should be noted as being concerned in the transmission of the weight by means of the sacrum:—1. The great size of that bone, affording evidence of the destination of man for the erect posture. 2. The obtuse angle at which the sacrum unites with the vertebral column, peculiar to the human species, and which becomes the seat of a decomposition of the force transmitted by the spine. Part of the momentum acting in the direction of the axis of the column, has no other effect than that of increasing the sacro-vertebral angle, at the expense of the flexibility of the inter-articular cartilage; the rest is transmitted to the sacrum, and then to the lower extremities. 3. The double wedge shape of the sacrum itself. In order to understand the advantage arising from this form, it is necessary to remark, first, that the weight of the trunk is transmitted in the axis of the upper half of the sacrum, and, consequently, in the direction of a line sloping downwards and backwards: from this it follows, that the sacrum must have a tendency to be displaced either downwards or backwards, but the displacement downwards is prevented by the position of the ossa innominata, which are nearer to each other below than above. The displacement backwards is obviated by the oblique direction of the articular surfaces of the same bones backwards and inwards, whilst the obliquity of the sacrum itself is in the opposite direction, for it is broader in front than behind.* 4. The distance intervening between the sacro-iliac and the coxo-femoral articulations. The articulation of the vertebral column with the pelvis being situated at the back part of that cavity, while those of the femora are situated towards the front, the distance between them increases the space in which the centre of gravity can oscillate, without being carried so far forward as to pass beyond the perpendicular let fall from the coxo-femoral articulation to the base of support.

In quadrupeds the haunch bones are placed in almost the same plane as the vertebral column. The fœtus and new-born infant somewhat resemble the lower animals in this respect, and therefore in the human subject there is a great tendency to assume the attitude of a quadruped during the first year of existence.

The weight received by the sacrum and transmitted to the haunch bones is divided, sometimes equally and sometimes unequally, between the sacro-iliac symphyses. One portion of the impulse calls into action the mobility of the symphyses, and the remainder is transmitted to the cotyloid cavities. It should be remarked, that this transmission is effected along the triangular prismatic columns, which form the sides of the inlet of the pelvis, and are the thickest and strongest parts of that structure. During the sitting posture, the weight of the body is transmitted to the tuberosities of the ischia, which from their great size are well fitted to support it. As these processes are situated in a plane very near the front of the pelvis, the centre of gravity of the trunk has a tendency to fall behind the basis of support represented by them; and therefore it is easy to push an individual backwards when in the sitting posture. The mode in which the pelvis resists violence, applied to the tuberosities

* Without admitting that the influences to which the sacrum is subjected have a tendency to force it backwards, as well as downwards, it is impossible to explain either the use of its being shaped like a wedge, with the base turned forwards, or of that powerful apparatus of posterior ligaments which can only resist its dislocation backwards. The idea that these forces tend to press it forwards, is manifestly at variance with the nature of the uniting media; for the sacro-iliac symphyses are only maintained in front by a very thin ligamentous layer, and the breadth of the space between the iliac bones is also greater in front than behind; circumstances that would evidently facilitate displacement forwards.

of the ischia in falls, is somewhat connected with its mechanism as adapted to the sitting posture. The shock is, in these cases, transmitted directly upwards in the direction of the acetabula, the lower hemispheres of which offer resistance like two arches: from the acetabula the impulse is communicated backwards by the thick columns extending from behind these cavities to the sacro-iliac symphyses; and forwards, to the symphysis pubis: so that falls upon the tuberosities are almost always accompanied with painful concussion both of the sacro-iliac and pubic symphyses.

In order to complete our account of the mechanism of the pelvis in standing, we must examine its mode of resistance in falls upon the knees or soles of the feet. In this case, the shock is communicated from below upwards to the upper halves of the cotyloid cavities, which are supported by the prismatic columns already described. The anterior part of each acetabulum presents a large notch, and is altogether unconcerned in the transmission of these shocks; so also is the very thin lamina, constituting the bottom or inner wall of the cavity, which can only suffer compression in falls upon the great trochanter.

During progression the pelvis affords to each thigh alternately a solid fulcrum, and receives itself a fixed point of support from the femur of that leg which rests upon the ground. While one side of the pelvis is thus supported upon one of the thigh bones, the other side is projected forwards. These alternate movements of projection of either side of the pelvis are much more marked in the female than in the male, and take place at the coxo-femoral articulation of the limb resting upon the ground.

3. *Mechanism of the pelvis with regard to parturition.* The art of midwifery depends in a great measure upon the study of the pelvis; it is impossible to form a true conception of the mechanism of natural labour, without being acquainted with the axes of the pelvis, its dimensions as compared with the size of the fœtus, the sacro-vertebral angle, the inclined planes of the true pelvis, the diameters of the brim and the outlet, and the malformations to which it is liable, Any lengthened details upon these points would be out of place here. I shall only remark, 1. that the existence of the arch of the pubes is peculiar to the human species; and 2. that the sciatic notches and the obturator foramina are not only useful from economising weight, but also because, corresponding as they do to the oblique diameters of the head of the fœtus during parturition, they render less painful the pressure attendant upon that process.

4. *Mechanism of the pelvis with regard to its own movements.* The intrinsic movements of the pelvis are very obscure, being confined to mere gliding motions, the production of which destroys part of the momentum from any external violence. The mobility of the intrinsic articulations of the pelvis is considerably increased during the latter periods of pregnancy, so that the coccyx may be pressed backwards, causing an increase of five or six lines in the antero-posterior diameter of the outlet; whilst the symphysis pubis * becomes susceptible of a slight separation, which increases (in a very slight degree, it is true, but sufficiently to merit notice) the dimensions of the brim of this cavity.

The extrinsic movements of the pelvis are those of flexion, extension, lateral inclination, and rotation: these are performed upon the vertebral column, and are all very limited. The motions of the pelvis upon the thighs are very considerable: they will be examined with the mechanism of the hip joint.

Coxo-femoral Articulation (*fig.* 76.).

Preparation. Remove with care all the muscles that surround the joint,

* In a female, seventy-nine years of age, the mother of nineteen children, I found the symphysis pubis extremely moveable: the two articular surfaces were contiguous; the inferior ligament had disappeared; and a very thick fibrous capsule of recent formation surrounded the articular surfaces in front, above, and below, being inserted at some distance from them.

preserving the reflected tendon of the rectus femoris. This articulation is the type of the order *enarthrosis*, being a true *ball and socket* joint.

The *articular surfaces* are the *globular head* of the *femur*, and the *cotyloid cavity* of the os innominatum. There is a striking difference between this joint and that of the shoulder, as far as regards the size of the articular head and the depth of the articular cavity. Both of the surfaces above-named are covered with cartilage, with the exception of two depressions, one of which is situated on the head of the femur, the other at the bottom of the cotyloid cavity; the latter is filled with a reddish adipose tissue, improperly called the *cotyloid gland*. It is analogous to the adipose tissue found in the neighbourhood of all the joints: its use is not well known; perhaps it is intended to protect the thin bottom of the cotyloid cavity from the effects of shocks or pressure.

Means of union. The *cotyloid ligaments* (*n*, *fig.* 76.). This ligament is attached to the margin of the acetabulum, which it as it were completes: it augments the depth of the cavity, and renders smooth its sinuous and notched circumference. It is of greater size at the notches than in any other part: by its means the irregularities of the edge of the acetabulum are effaced, and the deep notch in front and below is converted into a foramen for the passage of vessels to the fatty tissue and the interarticular ligament.

It is much thicker above and behind than below and in front, and it is precisely against the first two points that the head of the femur constantly presses. It is also remarkable in this respect, that the diameter of its free borders is smaller than that by which it is attached, and this circumstance assists in some degree in retaining the head of the femur in the cotyloid cavity. It consists of fibres which arise successively from all points of the circumference of the acetabulum, and interlace at very acute angles. This interlacement is especially visible in the situation of the great anterior notch, where the fibres may be seen arising from each side of the notch, and passing across each other.

The *capsular* or *orbicular ligament* (*p*, *fig.* 76.). This represents a fibrous sac having two openings, by one of which it embraces the acetabulum, outside the cotyloid ligament, whilst the other surrounds the neck of the femur. The femoral insertion of the capsular ligament requires to be carefully studied for the purpose of explaining the difference between fractures within, and fractures beyond, the capsule. This insertion is so arranged that at the upper part of the joint, it corresponds with the base of the neck of the femur, while beneath it is situated at the junction of the external with the two internal thirds of the neck. The length of the capsular ligament is exactly equal to the distance between its insertions, excepting at the inner part, where it is much more loose. Hence the extent of the motion of abduction, which is so remarkable in some jugglers that they are able to separate their legs, until they form right angles with the body, without producing dislocation.

The thickness of this ligament is not equal throughout: it is greatest above and on the outside, where the reflected tendon of the rectus muscle is situated; it is less thick behind, and still thinner on the inside. In front, the capsule is strengthened by a bundle of fibres stretched obliquely like a sling from the anterior inferior spinous process of the ilium to the inside of the base of the neck of the femur. It is called by Bertin the *anterior* and *superior ligament* (*r*, *fig.* 76.). Within this bundle the capsule is often imperfect, and permits a communication between the synovial membrane of the joint, and the bursa of the psoas and iliacus muscles. In one subject that I dissected, the communicating orifice was so large, that the common tendon of these muscles was in immediate contact with a considerable portion of the head of the femur; the tendon itself being split into several bands, some of which had been lacerated, and as it were worn away by friction.

The *external surface* of the capsular ligament is in relation with the psoas and iliacus muscles in front, being separated from them by a bursa at the upper part, and giving insertion to many of their fibres below On the inside, it is

in relation with the obturator externus and the pectineus; on the outside with the gluteus minimus; behind with the quadratus femoris, the gemelli, the pyriformis, and the obturator internus. The *internal surface* is lined by the synovial membrane.

The capsular ligament of the hip joint differs from the generality of such structures in being of a dull white, instead of a pearly white colour and in being composed of irregularly interlaced instead of parallel fibres. I have also observed a very remarkable fact, apparently overlooked by anatomists, viz. that it is extremely thin at both its orifices, but especially at the lower; that near this insertion it is strengthened by some circular fibres which embrace the neck of the bone like a collar, but without adhering to it; and that in its different movements this sort of collar rolls round the neck, but is retained in its place by small bundles of fibres reflected from the capsule upon the neck of the bone, which raise the synovial membrane from the surface.

The *interarticular* or *round ligament* (*t*, *fig.* 76.). This ligament arises from the depression on the head of the femur, becomes wider, and divides into two bundles, which are fixed to the edges of the cotyloid notch. The thickness and the strength of this interarticular ligament are extremely variable; sometimes it adheres to one edge only of the notch; sometimes it consists merely of a few ligamentous fibres, contained within the substance of the reflected synovial membrane; sometimes there is nothing but a fold of that membrane which may be torn by the slightest force; and lastly, it is not uncommon to find that it is altogether wanting.

The *synovial membrane* lines the whole internal surface of the capsular ligament, the two non-adhering surfaces of the cotyloid ligament, and that part of the neck of the femur contained within the joint; it embraces the round ligament, and sends off a prolongation from it to the fatty matter, at the bottom of the acetabulum, an arrangement which led the older anatomists to believe that the round ligament was inserted into the bottom of the cotyloid cavity

Mechanism of the Coxo-femoral Articulation.

Like all enarthroses, the coxo-femoral articulation can execute movements of flexion, extension, abduction, adduction, circumduction, and rotation.

1. In *flexion*, the head of the femur rolls in the cotyloid cavity around an imaginary axis corresponding with that of the neck of the bone. The lower end of the femur is carried from behind forwards, and describes the segment of a circle, whose radius is represented by the shaft of the bone. In the mechanism of this movement, the neck of the femur has the effect of substituting a rotatory motion of the head of that bone upon a fixed point, in which there is no tendency to displacement, for a very extensive movement backwards and forwards, which would otherwise have been necessary, and in which the surfaces would have been liable to separation from each other. We can indeed scarcely believe that luxation would be possible during this motion, although it can be carried so far that the front of the thigh and the fore part of the abdomen may be brought in contact.

2. *Extension* is effected by the same mechanism, but such is the obliquity of the acetabulum, which looks both forwards, outwards, and downwards, that when the femur is in the vertical direction, the head projects and carries forwards the fibrous capsule. The anterior reinforcing bundle is stretched. The psoas and iliacus muscles perform the office of an active ligament. Luxations of the femur forwards are not common, for the movement of extension is limited by the meeting of the edge of the acetabulum and the back part of the neck of the femur; and the ligament and muscles above named also tend to counteract it.

3 and 4. The mechanism of *adduction* and *abduction* is altogether different from that of the preceding movements, where the articulation forms the centre of a circle described by the femur, the radius of which is measured by a line stretched from the head of the bone to the space between the condyles. In

abduction, the head of the femur presses against the inner part of the capsular ligament; and, on account of the looseness of this ligament, the obliquity of the acetabulum, and the arrangement of the interarticular ligament, this movement may be carried very far without displacement, and is only limited by the meeting of the upper edge of the neck of the femur, with the rim of the cotyloid cavity. But this very meeting may itself become the cause of luxation, and then the edge of the cotyloid cavity may be regarded as the fulcrum of a lever of the first order with unequal arms, the whole length of the femur being the arm, to which the power is applied, and the neck of the bone, that by which the resistance acts.

In *adduction*, the femur moves in precisely the opposite direction: this motion is limited by the mutual contact of the two thighs, but by means of slight flexion it may be carried so far as to throw one over the other. The great depth of the upper and external part of the cotyloid cavity, and the strength of the capsular ligament in the same directions, would seem to oppose all displacement. But it should be observed that falls upon the knees almost always happen during adduction of the thighs, for this is an instinctive movement of preservation. However slight the adduction may be, the interarticular ligament is of necessity stretched; and from this it follows, as M. Gerdy has remarked, that the head of the femur is detached from the bottom of the cavity, by a kind of rolling of the round ligament upon it, and comes to press against the fibrous capsule. It may be conceived that luxation is necessarily preceded by rupture of the interarticular ligament.

5. *Circumduction* consists in the transition from one of these motions to another. The femur circumscribes a cone, of which the apex is in the joint, whilst the base is described by the lower end of that bone.

6. Independently of the movements above described, the coxo-femoral articulation performs *motions of rotation*. This movement should be studied both at the upper and at the lower part of the femur. At the upper part it is a motion of horizontal displacement, the radius being represented by the head and neck of the bone; at the lower part it is a rotatory motion of the femur, not precisely upon itself, but upon an imaginary axis placed on the inside of, and parallel to, the shaft. It follows, that there can be no rotation in cases of fracture of the neck of the bone, and this is one of the diagnostic signs of that accident. Lastly, it may be observed that rotation is performed from *without inwards*, or *from within outwards*: the latter is the more extensive and more natural movement; it is produced by a great number of muscles, and therefore during repose the point of the foot is slightly inclined outwards.

The Knee Joint (*figs.* 78. to 81.).

Preparation. 1. Make a crucial incision in front of the knee and dissect back the flaps. 2. Detach the aponeurosis of the thigh, preserving the fibrous band, which forms the continuation of the *tensor vaginæ femoris*. 3. Remove the aponeurosis of the triceps on the sides of the patella, taking care to avoid opening the synovial capsule. 4. Remove the tendon of the biceps, and turn downwards the tendons of the sartorius, gracilis, and semitendinosus. 5. Remove the popliteal vessels and nerves behind, and also the gastrocnemii. 6. After having studied the ligaments situated around the synovial capsule, isolate the latter as much as possible by dissecting off the lateral ligaments, and the ligamentum patellæ. 7. Open the synovial capsule above the patella. 8. Make a horizontal section of the femur immediately above the condyles, and a vertical section from before backwards between the condyles. These two sections are intended to expose the crucial ligaments.

The articulation of the knee belongs to the class of *angular ginglymi*. it is the largest and most complicated joint in the human body.

Articular surfaces. The lower end of the femur and the upper end of the tibia are the essential constituents of this joint, which is completed in front by

the patella. The articular surface of the femur is formed in front by the trochlea; and behind by the two condyles, separated by the intercondyloid fossa; the articular surface of the tibia consists of the glenoid cavities, separated by the spine of the tibia, in front of and behind which are some irregular projections. The patella presents two concave surfaces, separated from each other by a vertical ridge corresponding to the groove of the trochlea. These surfaces are all covered with a thick layer of cartilage. It should be remarked with regard to the knee-joint, 1. that the articular surfaces are rather placed in juxta-position, than jointed together; 2. that the articulation is in some measure double, since two very distinct condyles correspond to two equally distinct cavities.

Inter-articular cartilages. Like all joints that are exposed to much pressure, the knee is provided with inter-articular cartilages. They are two in number, and are named from their figure *semilunar* or *falciform cartilages* (*a b*, *fig.* 78.). Their upper surfaces, corresponding to the convexity of the condyles, are concave; their external circumference is very thick, and the internal sharp and thin: they therefore assist in deepening the concave surfaces of the tibia. The external inter-articular cartilage (*a*) covers almost the whole of the external glenoid cavity of the tibia, forming nearly a complete circle; while the internal cartilage (*b*) leaves a great part of the corresponding cavity uncovered. In this respect the inter-articular cartilages of the knee differ from all others of the same kind, for they do not establish a complete separation of the articular surfaces, between which they are placed. The external is attached by both extremities between the two projections that form the spine of the tibia; the anterior extremity of the internal cartilage is fixed in front of the spine, and the posterior extremity behind it; and hence, as these cartilages are inserted into the tibia, they accompany it in all its movements. A transverse fibrous band, called the *transverse ligament*, unites them in front; and from the external inter-articular cartilage, a very thick bundle of fibres proceeds backwards, which adds greatly to the strength of the posterior crucial ligament, and is inserted behind it into the internal condyle of the femur.

Fig. 78.

The *means of union* are two lateral, a posterior, an anterior, two crucial ligaments, and a synovial capsule.

The *external lateral ligament* (*a*, *figs.* 79 and 80.) extends from a small eminence, which separates two depressions on the back part of the external tuberosity of the femur, to the outside of the head of the fibula. This ligament has the rounded form, and the appearance of a tendon; it is situated in front of the tendon of the biceps, which covers it below, and embraces it by its bifurcation.

The *internal lateral ligament* (*b c*, *figs.* 79 and 80.) extends from the back of the internal tuberosity of the femur, below the tubercle for the adductor magnus to the inner edge and internal surface of the tibia. It consists of a broad and thin band, covered at its lower part by the tendons of the sartorius, gracilis, and semitendinosus muscles, a synovial bursa intervening. Its deep surface is applied to the anterior tendon of the semi-membranosus, and adheres intimately to the inter-articular cartilage. The lateral ligaments are situated much nearer to the back than to the fore part of the joint, so that they are stretched during extension, and assist in limiting that motion, but are relaxed, during flexion, to the performance of which they offer no obstacle.

The *posterior ligament* (or ligament of Winslow) is composed of several sets of fibres. Some (*c*, *figs.* 79 and 81.) pass obliquely upwards and outwards, being formed by a considerable expansion of the semi-membranosus; others proceed

from the tendons of the popliteus and gastrocnemius; and, lastly, some

• *Fig.* 79.

Fig. 80.

bundles, partly vertical and oblique, arise from above tl dyles of the femur, and : tached to the tibia. From tl lection of fibres running in ent directions, there resı irregularly interwoven li perforated by foramina that mit the ramifications of the articular artery: several most deeply-seated ligan bundles are inserted into the of the inter-articular cartilag in addition to these fibres, especially constitute the pc ligament, there is also a *semi-capsular fibrous membr* vering the back of each co it is closely united to the t of the gastrocnemius and taris muscles, which, indeed be regarded as forming acti terior ligaments of the knee

The sesamoid bone of t ternal head of the gastrocn when it exists, is found in tl stance of the external semi-c

The *anterior ligament* (*d*, and 81.), or ligamentum p is that portion of the comm don of the extensor muscles passes between the patella a tibia. It is very broad, thic almost triangular, and is co ous in front of the patella w tendon of the extensor musc means of a superficial la fibres. It arises by a broad insertion from the apex of the patella and

Fig. 81.

from its anterior surface, but not from the roug jections behind the apex, and it proceeds, conti as it descends, to the most prominent and lowe of the anterior tubercle of the tibia. Behind th ment there is a considerable quantity of fatty (*e*, *fig.* 81.), which separates it from the articul synovial membrane; and a very distinct bur separates it from that portion of the anterior tı over which it glides.

Crucial or *interosseous ligaments.* In the inte the knee-joint there are two interosseous lig (*g i*, *fig.* 78.), so arranged as to admit of the m tensive flexion, but to limit the movement of ext They are called *crucial*, because they cross eacl like the letter X. They are situated in the d ter-condyloid fossa. The *anterior* (*g*, *figs.* 78. a arises from the external condyle and passes forepart of the spine of the tibia. The *p* (*i*, *fig.* 78.) arises from the internal condyle, and is fixed to the back

the spine, and also to the external semilunar cartilage. The names anterior and posterior have been taken from their insertions, for at their origins the anterior is attached *behind* the external, and the posterior *in front* of the internal condyle. From their obliquity, and their situation nearer to the back part of the joint, they are well adapted for limiting the movement of extension, during which their points of insertion are separated, whilst during flexion they are approximated.

The *synovial capsule* of this joint is the largest and the most complicated of all that exist in the body. In tracing it from the upper edge of the patella we find, behind the tendon of the extensor muscles, a large cul-de-sac (*s*, *fig.* 81.), sometimes replaced by a distinct synovial capsule, interposed between that tendon and the surface of the femur. In some subjects, this bursa communicates with the synovial capsule of the knee-joint by a more or less considerable opening, and in such cases a circular constriction forms the only trace of separation. On each side of the patella the synovial membrane extends beneath the two vasti, but particularly beneath the vastus internus. The existence of these two prolongations affords an explanation of the swellings observed at the sides of the knee in dropsy of this joint; and the greater extent of the internal prolongation explains also the greater size of the prominence on the inner side. In the intercondyloid notch the synovial membrane envelopes the crucial ligaments; then it is reflected upon the posterior ligament, the lateral ligaments, the semilunar cartilages, the articular surfaces of the tibia, and, lastly, the back of the ligamentum patellæ; it next sends off a prolongation, containing a few ligamentous fibres, and extending from the lower border of the patella to the front of the intercondyloid notch. This fold has been incorrectly termed the *adipose ligament* (ligamentum mucosum, *t*, *figs.* 78. and 81.). After having furnished this fold, the synovial membrane lines the posterior surface of the patella, and becomes continuous with the cul-de-sac behind the extensor tendon. Sometimes the prolongation, known as the adipose ligament, does not exist; at other times there is more than one. I have seen a fold of the same nature extending from that part of the synovial membrane which lines the extensor tendon to the surface of the femur above the trochlea. No other synovial membrane in the body is provided with so large a number of villous prolongations, which, in some subjects, may be said to give it a shaggy appearance; they are especially met with around the patella * and the semilunar cartilages. To these prolongations Clopton Havers has given the name of *synovial fringes*. Some deep fibres of the triceps cruris have been regarded as a special tensor muscle of the synovial capsule. (Vide *Triceps Cruris*, MYOLOGY.)

Sub-synovial adipose tissue. From the abundance of this tissue in the knee-joint, its disposition requires some special notice. It is chiefly met with behind the ligamentum patellæ (*e*, *fig.* 81.), where it forms a very thick layer, filling up the interval between the patella and the synovial membrane. A great quantity is also found behind the tendon of the triceps, above the condyles where it occupies the space between that tendon and the corresponding part of the femur. Lastly, it is found around the condyles in the inter-condyloid fossa, surrounding the insertions of the crucial ligaments. This fatty tissue, which is observed even in individuals wasted by marasmus, but is then more serous, being as it were infiltrated, has no other apparent use than that of filling up such intervals as are left between the articular surfaces in some positions of the joint.

We must add to this list of the uniting media of the knee-joint, 1. a very strong superficial external lateral ligament (*c*, *fig.* 80.) derived from the fascia lata and inserted into the anterior tuberosity of the tibia, the projection of which has reference to such insertion; 2. an aponeurotic layer (*e*) attached

* [Two slight folds of the membrane formed at the sides of the patella, have been particularly described under the very inappropriate name of the *alar ligaments*.]

to the inner side of the patella, and to the internal surface of the tibia, formed by one of the insertions of the vastus internus; 3. a proper ligament of the patella (*f*), extending from the external condyle of the femur to the outer edge of this bone. 4. To these may be added the femoral aponeurosis, which is prolonged around the entire joint; an expansion of the aponeurosis of the vastus internus that covers the patella; and, lastly, a thin layer of fibrous tissue belonging to the synovial membrane

Mechanism of the Femoro-tibial Articulation.

1. *With regard to strength.* The strength of articulations is generally in direct proportion to the extent of the articular surfaces, and there is no joint more advantageously constructed in this respect than the one we have been examining. The reception of the spine of the tibia into the inter-condyloid fossa also tends greatly to increase the strength of the joint, although it forms but an imperfect kind of dove-tailing. A third and last condition conducive to strength is the multiplicity of the ligaments.

2. *With regard to mobility.* The knee being a hinge-joint has two principal movements, in opposite directions, viz. *flexion* and *extension;* but as the mutual reception of the surfaces is very imperfect, it is also capable of some slight *rotatory motions.*

In *flexion*, the surfaces of the tibia, defended by their inter-articular cartilages, glide backwards upon the condyles of the femur: and from the great extent of the articular surfaces of the last bone in that direction, the movement can be carried so far as to permit the leg and thigh to touch. In this movement, the lateral, the posterior, and the crucial ligaments are relaxed; the ligamentum patellæ is stretched; the patella is firmly applied to the front of the joint, and can neither be moved to the right nor to the left, as may be done during extension. In the position of flexion, the patella fills up, as it were, the great hiatus then existing at the front of the joint between the femur and the tibia. Luxation is impossible during this movement, which is only limited by the mutual contact of the leg and the thigh.

In extension, the tibia and the inter-articular cartilages glide in the opposite direction. The movement is arrested when the leg is in the same line as the thigh, and whatever muscular effort be then made, the leg can never pass that limit, excepting from malformation of the parts. A greater amount of extension is rendered impossible, both by the shape of the articular surfaces, and by the stretching of all the ligaments, excepting that of the patella, which is completely relaxed, and permits of a great lateral mobility of that bone. One circumstance in the shape of the articular surfaces, opposed to any extension beyond the straight line, is the small extent of the trochlea in front; for, could such extension take place, the glenoid cavities of the tibia would then be applied to a portion of the trochlea, much smaller than themselves. The crucial ligaments are especially intended to limit the movement of extension, as the following experiment will at once demonstrate. Divide all the external ligaments of the joint, and then endeavour to extend the leg beyond the ordinary limits; this will be found impossible until the other ligaments are divided. An analogous experiment, in which all the ligaments of the joint (even including the crucial) are divided, excepting the lateral, proves that these are not only opposed to lateral movements, but also limit extension; this they are enabled to do from being situated nearer to the back than to the front of the joint. Complete luxation can only be effected after laceration of all the ligaments which limit extension.

In all these motions the patella is fixed; it is the femoral trochlea which glides upwards or downwards upon the posterior surface of that bone. This almost invariable position of the patella depends on the inextensibility of its ligament. The existence of the patella has no effect in limiting the movements of extension; its only uses, as far as the joint is concerned, are to protect it in

front, and to prevent painful pressure in the kneeling posture. Its other and chief uses are connected with the functions of the triceps extensor muscle, in the tendon of which it is developed. It is moveable and depressed during extension of the leg, but during flexion it becomes prominent and fixed.

Rotation. When the leg is semi-flexed upon the thigh, it can be very slightly rotated inwards and outwards. These movements are performed not upon the external but upon the internal condyle as a pivot, so that the external part of the head of the tibia glides forwards during rotation inwards, and backwards during rotation outwards. The difference in the part performed by the two condyles in the movement of rotation, does not depend upon any peculiarity of structure in the joint, but exclusively upon the arrangement of the acting forces, as we shall see when treating of the muscles. Rotation inwards is limited by the mutual contact of the crucial ligaments, whose decussation is increased during this movement. Rotation outwards is more extensive, because in this movement the ligaments are uncrossed and become parallel. We shall see *hereafter* that the biceps is the agent of rotation outwards, and the popliteus of rotation inwards.

Peroneo-tibial Articulations (*figs.* 79 and 80.).

Preparation. 1. Remove carefully the muscles of the anterior and posterior regions of the leg, which will expose the interosseous ligament, and the anterior and posterior ligaments of these joints. 2. In order to see the interior of the articulations, saw through the two bones in the middle, and then separate them. 3. To gain an idea of the interosseous ligament of the inferior articulation, saw perpendicularly through the lower ends of the bones of the leg so as to divide them into an anterior and a posterior portion.

The tibia and the fibula, which are contiguous at their extremities, are separated from each other along their shafts, the interval being occupied by an aponeurosis, improperly called *the interosseous ligament.* We have, then, a superior and an inferior peroneo-tibial articulation, and an interosseous ligament or aponeurosis.

1. *Superior Peroneo-tibial Articulation.*

This articulation is an *arthrodia.* The articular facette of the tibia, looking downwards and outwards, is situated behind its external tuberosity. The facette of the fibula looks upwards and inwards; it occupies the inner part of the upper end of the bone. The *means of union* are two ligaments — an anterior (*g, fig.* 80.) and a posterior (*d, fig.* 79.). They are composed of parallel fibres, directed obliquely downwards and outwards from the external condyle of the tibia, to the head of the fibula. There is generally a distinct synovial membrane for this joint, but sometimes it is a prolongation from the capsule of the knee.

2. *Inferior Peroneo-tibial Articulation.*

This articulation is an *amphiarthrosis,* that is, it is formed between surfaces that are partly contiguous, and partly continuous. The former consists of two articular facettes, narrow from above downwards, and oblong from before backwards; of these one is convex, and situated upon the internal surface of the lower end of the fibula above the malleolus; the other is concave and continuous with the inferior or tarsal articular surface of the tibia. They are both covered with cartilage. The continuous surfaces are rough and much more extensive; they are triangular in shape, having their bases directed downwards: the one situated upon the fibula is convex, that upon the tibia is slightly concave.

The *means of union* are, two ligaments external to the joint, and an interosseous ligament connecting the two triangular surfaces just mentioned. Of the two external ligaments, one is *anterior* (*i, fig.* 80.), and the other *posterior*

(*e*, *fig*. 79.). They are both very strong, and composed of thick, shining, parallel fibres, which pass obliquely downwards and outwards from the tibia to the fibula. They are almost always divided into two distinct bundles. They are both remarkable from descending beyond the articular surfaces, so that they increase the depth of the cavity for the reception of the astragalus. The *synovial membrane* of this articulation is a prolongation from that of the ankle-joint. The interosseous ligament consists of fibrous bundles, mixed with adipose tissue, which unite the two triangular surfaces so firmly that the fibula is sometimes fractured in attempting to rupture the ligaments.

3. *Interosseous Aponeurosis.*

The name of interosseous ligament is given to an aponeurotic septum (*b*, *figs*. 79 and 80.), placed between the muscles of the anterior and those of the posterior aspect of the leg; it should rather be regarded as serving to multiply the points of insertion for fibres of those muscles, than as a means of union between the bones of the leg. It is narrower below than above, and is composed of fibres running obliquely downwards and outwards from the outer edge of the tibia to the longitudinal crest on the inner surface of the fibula. As in the interosseous ligament of the fore-arm, we find some other fibres crossing the former at an acute angle. The septum thus formed is interrupted above and below for the passage of the tibial vessels; the peroneal artery and veins traverse the lower opening; the anterior tibial artery and veins pass through the upper.

Mechanism of the Peroneo-tibial Articulations.

The fibula is only capable of almost imperceptible gliding movements upon the tibia. This arrangement is directly connected with the mechanism of the ankle-joint.

Ankle, or Tibio-tarsal Joint (*figs*. 79 and 80.).*

Preparation. Cut and turn back the tendons that are reflected round the joint, and remove the sheaths of those tendons by which most of the ligaments are covered.

The tibio-tarsal articulation belongs to the class of *angular ginglymi.*

Articular surfaces. Both bones of the leg participate in this joint, their lower extremities being united to form a transversely oblong socket, of which the tibia constitutes by far the greater part. On this articular surface there is an antero-posterior ridge, corresponding to the groove of the trochlea on the astragalus, and separating two shallow cavities. The socket is bounded by the malleoli on each side. The internal or tibial malleolus corresponds to the internal lateral articular surface of the astragalus; and the external or fibular malleolus, to the external lateral facette of the same bone. The superior articular surface of the astragalus is a trochlea; it is oblong from before backwards, thus contrasting with the cavity on the lower extremity of the leg, which is transversely oblong. This trochlea presents a shallow depression, running from before backwards, and having an external and an internal edge, the external being the more elevated of the two. The pulley of the astragalus is continuous with its lateral articular surfaces, of which the external is by far the larger.

The *means of union* are three external lateral ligaments, two internal lateral ligaments, an anterior (*r*, *fig*. 80.) and a posterior (*s*, *fig*. 79.) ligament, and a synovial capsule.

The *external lateral or peroneo-tarsal ligaments* are three in number; they all proceed from the fibula, either to the astragalus, or the os calcis.

1. The *external lateral ligament*, properly so called (ligamentum fibulæ me-

* We should remark that, in order to study this as well as all the other articulations efficiently, it is a great advantage to be provided with two joints, of which one is opened, whilst the other has its ligaments untouched.

dium vel perpendiculare, *m*, *figs.* 79 and 80.), is situated beneath the sheath of the peroneus longus and brevis. It arises from the summit of the external malleolus, is directed downwards and slightly backwards, to be attached to the outside of the os calcis. It is rounded and composed of parallel fibres.

2. The *anterior external lateral ligament* (ligamentum fibulæ anterius, *n*, *fig.* 80.), arises from the anterior edge of the external malleolus, and proceeding downwards and forwards is fixed to the astragalus in front of its external malleolar facette. It is very short, and broader below than above: it forms one of the two anterior ligaments described by Bichat in this joint.

3. The *posterior lateral ligament* (ligamentum fibulæ posterius, *o*, *fig.* 79.) is very deeply seated behind; it extends from the excavation on the inside and behind the external malleolus to the posterior border of the astragalus. It is directed almost horizontally, or in a slight degree obliquely downwards and inwards, and is almost parallel to the posterior ligament of the lower peroneo-tibial articulation. It is composed of very distinct parallel fibres. Bichat calls it the posterior ligament of the joint.

The *internal lateral ligament* is much stronger than the three external ligaments taken together. It is composed of two very distinct layers: 1. a *superficial layer*, consisting of fibres stretched from the apex and the anterior and posterior borders of the internal malleolus to the os calcis, and the upper edge of the lower calcaneo-scaphoid ligament, which it maintains in a state of constant tension. The fibres are long, and slightly divergent, but still sufficiently so to have given origin to its name of the *deltoid ligament* (*p*, *figs.* 79 and 80.). The fibres which are most anterior pass directly forwards to the neck of the astragalus and to the scaphoid; they form a very thin layer which has been improperly called the anterior ligament of the ankle-joint. 2. Below the above is a *deep layer* of much greater extent, composed of short and strong bundles, passing downwards and outwards from the summit and sides of the internal malleolus, to the inner surface of the astragalus, below the articular facette.*

Synovial capsule. The external surface of this membrane is brought into view in front and behind, by removing the tendons and their sheaths; and if the external and internal lateral ligaments be divided, it will be seen to extend into the inferior peroneo-tibial articulation. It will also be observed that it is tense at the sides, but very loose behind, and more particularly so in front. A great quantity of adipose tissue covers its external surface in these situations.

Mechanism of the Ankle-joint.

This articulation not only constitutes the point at which the weight of the body is transmitted to the foot, but also performs a very active part in the movements of progression; it is therefore so constructed as to unite great strength with the capability of tolerably extensive motion.

With regard to strength, the following arrangements should be noticed as especially advantageous: 1. The leg being articulated with the foot at a right angle, transmits the weight of the body directly to it, and this transmission being effected in the perpendicular direction, *i. e.* in a direction in which the articular surfaces mutually oppose each other, has no tendency either to produce fatigue, or to rupture the ligaments. The perpendicular position of the leg upon the foot during standing, is worthy of notice, because of itself it proves that man was intended for the erect posture, since in this attitude alone does the entire inferior surface of the foot rest upon the ground. It

* [The author has omitted, perhaps intentionally, to give a special description of the anterior and posterior ligaments of the ankle-joint, already alluded to by him. The former extends from the anterior margin of the articular surface of the tibia. to the corresponding border of the astragalus, and is called the *tibio-tarsal ligament*; it is very thin, and covered by the tendons of the extensor muscles. The posterior can scarcely be said to exist as a distinct ligament.]

should be also remarked that there is no other articulation, excepting that of the head upon the vertebral column, in which the parts united are habitually perpendicular to each other. 2. The dovetailing effected at this joint, by the reception of the astragalus into the socket, formed by the bones of the leg, is also highly conducive to its strength. This dovetailing results both from the pulley-like surface of the astragalus and from the angular form of the tibio-fibular socket; and it should be observed that this latter condition is, as it were, peculiar to the ankle joint, for in no other do we meet with such abrupt angles.

With regard to mobility, the tibio-tarsal articulation admits of flexion and extension. There is no lateral motion, the movements of the foot in this direction being almost exclusively performed at the tarsal joints.

In flexion, the astragalus glides backwards upon the tibia and fibula, and the back part of the pulley projects behind. Luxation, from an excess of this movement, is almost impossible, for it is limited by the meeting of the neck of the astragalus and the anterior edge of the tibio-fibular sockets. In this movement the posterior external lateral ligament, and the middle and posterior fibres of the internal lateral ligament, are put upon the stretch.

In extension, on the contrary, the trochlea of the astragalus glides forwards upon the corresponding surface; the synovial membrane is borne upwards in front; the anterior external lateral ligament, and the anterior and middle fibres of the internal lateral ligament, are stretched. Luxation is possible during this motion, but is very rare.

Lateral movements. Although the shape of the joint is opposed to movements of this kind, yet it cannot be doubted that the elasticity of the fibula, by allowing the external malleolus to yield a little, may permit them in a slight degree. Nevertheless the fibula must be fractured if any force, exerted by the astragalus against the external malleolus, be carried so far as to thrust it much outwards.

Articulations of the Tarsus (*figs.* 80. 82, 83, 84.).

The intrinsic articulations of the tarsus comprise, 1. the articulations of the component bones of each row; 2. the articulation of the two rows together.

Preparation. 1. Remove the tendons situated upon the dorsum of the foot, and also the extensor brevis digitorum muscle. 2. Remove all the muscles of the plantar region. 3. Rub off, by means of a rough cloth, the adipose tissue covering the ligaments: (a subject much infiltrated with serum is best adapted for this purpose). 4. In order to gain a clear comprehension of the articulation of the two rows together, remove the astragalus from the sort of box in which it is contained, by dividing the interosseous ligament which unites it to the os calcis. 5. For the examination of the interosseous ligaments, it is necessary to separate the bones by laceration or section of those ligaments; the resistance experienced in doing this, and the portions of the ligaments remaining attached to the bones, will give a good idea of their strength and situation. 6. In order to obtain a correct notion of all the ligaments together, it is necessary, while studying each, at the same time to examine a foot in which all the joints have been opened above, whilst the bones are still retained in their situations by means of the plantar ligaments.

Articulation of the component Bones of the first Row, or Articulation of the Astragalus with the Os Calcis.

This is a double arthrodia, in which each of the bones presents two articular facettes, separated by a furrow deeper on the outer than on the inner side. The posterior surface of the astragalus (1, *fig.* 84.) is concave, that of the os calcis (2) is convex; in front (1) the opposite obtains, so that there is a mutual reception

parts. The means of union, properly speaking, consist only of an extremely strong *interosseous ligament* (*a*, *fig.* 84.), formed by ligamentous bundles, of which some are vertical, and others oblique; they are mixed with fat, and occupy the considerable interval formed by the grooves of the two bones, and which is larger towards the outer end. To form a complete idea of this ligament, it is necessary to make a vertical section, from before backwards, through the middle of the astragalus and os calcis (as in *fig.* 84.). A loose synovial membrane lines the *posterior articulation*, which is strengthened on the inside by the fibrous sheaths of the tendons of the tibialis posticus, the flexor longus digitorum, and the flexor longus pollicis. There are also about this joint two very small fibrous bundles, one of which is posterior (*t*, *fig.* 80.; *a*, *fig.* 83.), and the other external (*b*, *fig.* 83.): some anatomists have described them by the names of *posterior* and *external ligaments*. The *anterior* portion of this articulation is often double, from the division of the anterior articular surfaces into two smaller facettes: it forms part of the astragalo-scaphoid articulation, with which it will be described.

Fig. 82.

Articulations of the Component Bones of the Second Row.

All these joints are very compact, for the five bones which constitute this row act as one only in the movements performed by the foot at its tarsal articulations. They present for the most part angular facettes; they have also interosseous ligaments, and are true symphyses or amphiarthroses.

Fig. 83.

Articulations of the Cuneiform Bones with each other.

Articular surfaces. The corresponding surfaces of the first and second cuneiform bones present contiguous as well as continuous portions. The contiguous portions are square, and situated at the upper and back part of each surface. The continuous portions are placed in front of the preceding. The corresponding articular surfaces of the second and third cuneiform bones are smooth and contiguous behind, but rough and irregular in front.

Means of union. 1. By *dorsal ligaments* (*c c*, *fig.* 83.). This name is given to some very compact fibrous bands stretching transversely from one bone to the other. By their upper surfaces, on which the longest fibres may be seen, they are in relation with the extensor brevis digitorum and with the tendons of the other extensor muscles. Their lower surfaces, the fibres of which are shorter, correspond to the articulations, and to the periosteum of the cuneiform bones, with which they interlace. 2. By *plantar ligaments*. This name may be given to some of the fibres of the interosseous ligaments. 3. By *interosseous ligaments*. These, which are very

strong, constitute the principal means of union of these joints, and occupy all the rough portions of the corresponding facettes. They so closely unite the bones, that, even when the dorsal ligaments are removed, it is not easy to open the joints.

The *synovial membrane* is merely a portion of the general synovial membrane of the tarsus.

Articulations of the Scaphoid with the Cuneiform Bones.

Articular surfaces. The scaphoid presents the only example in the body, of a single articular surface being divided into three facettes by well-marked ridges. Each of these facettes is triangular, and corresponds to a surface of the same form on one of the cuneiform bones. The base of the triangular facette for the first cuneiform bone, is below: the bases of the other two are above (3, *fig.* 80.).

Means of union. 1. *Dorsal ligaments.* There are two for the first cuneiform bone, a superior (*d, fig.* 83.), and an internal (*e, figs.* 83 and 84.); and only one for each of the others (*f f, fig.* 83.). The dorsal ligaments of the first cuneiform bone pass directly backwards; those of the other two are stretched obliquely forwards and outwards. 2. *Plantar ligaments.* A very strong plantar ligament (*a, fig.* 82.) extends from the tubercle of the scaphoid to the corresponding tubercle of the first cuneiform bone; it is blended with the tendon of the tibialis posticus, which furnishes a considerable expansion that crosses the direction of the tendon of the peroneus longus, and extends to the third cuneiform, and the corresponding metatarsal bone; it may be considered as an inferior ligament of the tarsus. The name of *plantar ligaments* can scarcely be given to some irregular fibres (*b, fig.* 82.), passing from the lower surface of the scaphoid to the second and third cuneiform bones.

A *synovial membrane*, common to the three articulations, is continuous with that of the three cuneiform bones.

Articulation of the Third Cuneiform Bone with the Cuboid.

This articulation resembles in every respect those of the cuneiform bones. The means of union are a *dorsal ligament* (*g, fig.* 83.), consisting of a very strong transverse bundle; an *interosseous ligament*, which occupies the entire non-articular portion of the corresponding surfaces; and an ill-defined *plantar ligament*, consisting of some irregular transverse fibres. The *synovial membrane* communicates with that of the cuneo-scaphoid articulations.

Articulation of the Scaphoid with the Cuboid.

The scaphoid and the cuboid often unite by a small facette. The means of union are an *oblique dorsal ligament* (*i, fig.* 83.); a very strong *interosseous ligament*, occupying the whole of the corresponding surfaces of the bones, excepting the small portions which are contiguous; and a very thick transverse *plantar ligament*, extending somewhat obliquely from the tuberosity of the scaphoid to the cuboid. These ligaments exist even when there are no articular facettes.

Articulation between the Two Rows of the Tarsal Bones.

The articulation between the two rows consists of the articulation of the the astragalus with the scaphoid and os calcis, the articulation of the os calcis with the cuboid, and, lastly, the union of the os calcis to the scaphoid by means of several ligaments.

1. *Articulation of the Astragalus with the Scaphoid.*

The articular surface on the *head* of the astragalus (1, *fig.* 84.), elongated from without inwards, and from above downwards, is larger than the *glenoid*

cavity of the scaphoid (3), and projects considerably below it, where it articulates with the anterior facette, or the two anterior semi-facettes of the os calcis. The cavitv of reception is completed by a ligament called the *inferior calcaneo-scaphoid*(*b*), which occupies the triangular interval between the small tuberosity of the os calcis and the scaphoid, and forms by itself the inner side of the cavity of reception. In order to obtain a good view of this ligament, it is advisable to remove the astragalus by cutting and tearing the interosseous ligament that unites it to the os calcis: it will then be seen, that the ligament we are describing is very strong and triangular, and that it covers not only the lower, but the inner part also of the head of the astragalus. It is often divided into two parts; one being external, narrow, and shaped like a band; the other internal, much broader and thicker, in relation below with the sesamoid bone of the tendon of the tibialis posticus, and presenting a cartilaginous thickening at the corresponding point.

Another ligament, called the *superior calcaneo-scaphoid* (*l*, *fig.* 83.), must also be regarded as contributing to wedge in the astragalus; it extends from the inside of the anterior extremity of the os calcis to the outside of the scaphoid. It is situated upon the dorsum of the foot, in the deep hollow occupied by fat, on the outer side of the astragalus. These two ligaments (the inferior and superior calcaneo-scaphoid) constitute the means of union between the os calcis and the scaphoid. These bones are in no part contiguous; but occasionally we find the os calcis continued into the scaphoid, through the medium of an osseous lamina, which replaces the lower calcaneo-scaphoid ligament.*

The os calcis being very securely articulated with the astragalus, and at the same time very firmly connected with the scaphoid, it follows that the articulation between the scaphoid and astragalus possesses great strength, although the ligaments directly uniting them are by no means powerful; just as the atlas, which is but slightly connected with the occipital bone by means of its own ligaments, is very firmly fixed by the ligaments stretching from the occipital bone to the axis. Nevertheless, the absence of any very strong and direct means of union between these bones, renders it possible for the astragalus to be forced by external violence out of the sort of osseo-fibrous socket in which it is placed.

The *superior astragalo-scaphoid* ligament (*s*, *fig.* 80.; *m*, *figs.* 83 and 84.) is the only one proper to this joint; it is semicircular in form, and extends somewhat obliquely forwards and outwards, from the neck of the astragalus to the margin of the facette on the scaphoid. It is thin in texture, and consists of parallel fibres; it is covered by the extensor brevis digitorum above, and is lined below by the synovial membrane of the articulation between the scaphoid and the astragalus.

2. *Calcaneo-cuboid Articulation.*

This articulation is upon the same line as the astragalo-scaphoid; an anatomical fact which has suggested the ingenious idea of a partial amputation of the foot between the two rows. It belongs to the class we have designated

* I have represented a case of this nature (vide *Anat. Pathol.* avec Planches, liv. ii. pl. iv.).

articulations by *mutual reception*, and of which we have found examples in the sterno-clavicular joint, and the carpo-metacarpal articulation of the thumb.

Articular surfaces (2, *fig.* 80.). The facette of the os calcis is concave from above downwards, while the surface of the cuboid is concave transversely, that is, in a direction at right angles to that of the former. At the lower part of the facette of the os calcis there is a horizontal projection, which sometimes stops the knife during the disarticulation of the two rows.

The *means of union* consist of three ligaments; an inferior or plantar, an internal, and a superior. The *inferior plantar*, or *calcaneo-cuboid ligament* (ligamentum longum plantæ, *c d*, *figs.* 82. and 84.), is the strongest of all the tarsal ligaments, forming a broad band of pearly white fibres, directed from before backwards. These fibres constitute a very thick bundle, and extend from all the under surface of the os calcis, excepting the posterior tuberosities, to the posterior margin of the groove of the cuboid. If the fibres of this ligament be removed layer by layer, we soon arrive at a more deeply seated ligament, separated from the first by some fatty tissue: it extends obliquely inwards from a tuberosity at the fore part of the under surface of the os calcis, to all that portion of the inferior surface of the cuboid, situated behind its groove. There are, therefore, two inferior calcaneo-cuboid ligaments; a deep (*c*), and a superficial (*d*).

The *internal calcaneo-cuboid ligament* (*n*, *fig.* 83.) is short, narrow, quadrilateral, and very strong; it is placed at the side of the superior calcaneo-scaphoid ligament, in the deep excavation between the astragalus and the os calcis. These two ligaments are separated in front, but blended together behind, so as to resemble the letter Y. They may be considered as in some measure forming the key of the articulation of the two rows of tarsal bones; for, during disarticulation the articular surfaces are easily separated as soon as they are divided.

The *superior calcaneo-cuboid ligament* (*o*, *fig.* 83.) is only a very thin small band of fibres, extending directly forwards, from the os calcis to the cuboid.

Mechanism of the Tarsal Articulations.

We should examine the mechanism of the tarsal articulations both as regards their strength and their mobility.

With regard to strength. The tarsus forms the fundamental part of the foot; one might, in fact, consider the metatarsus and the toes as superadded structures, for, even when they are removed the foot fulfils its office as a basis of support very efficiently. Surgeons avail themselves of this fact in performing partial amputations of the foot, at the tarsal and tarso-metatarsal articulations.

The construction of the tarsus is, in every respect, adapted to ensure strength; the number of its pieces, the breadth of the articular surfaces, the strength of the interosseous ligaments, and even the mobility of its component bones, all conduce to this end. Suppose, for example, that a single bone had occupied the place of the seven bones in the tarsus, how liable would this long and cancellated lever have been to fractures from the violent shocks to which it is constantly exposed, or from the influence of muscular contraction? The tarsus is narrow behind, but enlarged before, so as to increase the transverse extent of the supporting base in that direction; it is articulated with the leg at a right angle, and, therefore, receives directly the weight of the body, and as directly transmits it to the ground. In order to provide the arm of a lever for the power which raises the weight of the body, it projects behind the leg; indeed, the fitness of an individual for running and leaping may be, in some degree, calculated from the length of his heel, or, what is the same thing, from the prominence of the tendo Achillis. In standing upon the sole of the foot, the weight of the body is transmitted by the tibia to the astragalus, and from thence to the os calcis. Part of the momentum is lost at the articulation between

these bones, and it is easy to comprehend why they are super-imposed, and not arranged in mere juxta-position. But the astragalus is not placed horizontally above the os calcis, for it inclines inwards, downwards, and forwards; and from this circumstance, even in standing upon the soles of the feet, the weight of the body is distributed between the os calcis and the anterior range of the tarsus, which is itself subdivided into two rows, but only on the inside, because it is there chiefly that the weight of the body is transmitted by the astragalus. In one attitude, this weight is communicated by the astragalus exclusively to the front row, viz. in standing upon the point of the foot; and it is then that the division of the tarsus into several bones is especially useful in preventing the injurious effects of shocks transmitted from below. There is an immense difference also, as regards their effects on the system, between falls upon the heels, and those upon the points of the feet.

The mechanism of the tarsal articulations, with respect to *mobility*, should be first studied in the two ranges separately, and afterwards in the articulation of the two rows together.

1. The bones of the first range, viz. the astragalus and the os calcis, *glide* upon each other from before backwards and from side to side. The *lateral glidings* assist in the *torsion* of the foot, which, however, is chiefly performed at the articulation between the two rows. The *antero-posterior glidings* take place under the following circumstances: when the weight of the body presses upon the upper part of the astragalus this bone slips a little forwards, and the foot has a tendency to become elongated, or flattened from above downwards, as Camper has remarked. When the pressure ceases the astragalus returns to its original position. The truth of the assertion, that the foot is an elastic arch, is chiefly established by reference to the nature of the astragalo-calcanian joint.

2. The bones of the second row are capable of such very slight gliding movements, that they may be considered as forming but a single piece. However, the articulation between the scaphoid and the cuneiform bones is somewhat more moveable than those of the cuneiform bones with each other and with the cuboid.

3. The chief movements of the tarsus take place between the two rows, and the articular surfaces are there very favourable to mobility; for there is in one part a head received into a cavity (at the astragalo-scaphoid articulation), and in another a mutual reception (at the calcaneo-cuboid articulation). These movements consist of a *sort of torsion* or *rotation*, by means of which the sole of the foot is carried either inwards or outwards. Assisted by slight lateral motions of the astragalo-calcanian joint, they constitute what is called *adduction* and *abduction* of the foot. They are generally attributed to the ankle-joint; but, as we have seen, that articulation is limited to flexion and extension; the sprains, therefore, which result from too extensive movements, either outwards or inwards, take place at the articulation of the two tarsal ranges, and not at the ankle-joint. When the movement of torsion is carried too far, the external malleolus is forced somewhat outwards; slight gliding motions occur at the tibio-fibular articulations; the elasticity of the fibula is called into play; and, if the violence be immoderate, the fibula is fractured.

Tarso-metatarsal Articulations (*figs.* 82 to 84.).

In the formation of these joints the wedge-shaped tarsal extremity of each metatarsal bone is opposed to one of the bones of the tarsus, the corresponding surfaces being plane and triangular. The first metatarsal bone articulates with the first cuneiform; the second metatarsal with the second, and slightly with the first and the third cuneiform bones; the third metatarsal with the third cuneiform; the fourth and fifth metatarsal with the cuboid. From this there results an angular articular line, commencing on the outside at the projection formed by the tuberosity of the fifth metatarsal bone. This line is directed obliquely forwards and inwards; it forms an angle at the third, and again

tilage, and consists of interlacing fibres: its edges are continuous, partly with the sheath of the flexor tendons, partly with the transverse metatarsal ligament, but especially with the lateral ligaments of the joint. It is grooved below for the flexor tendons, concave above to correspond with the convexity of the head of the metatarsal bone, and completes the cavity in which that head is received. Its anterior edge is very firmly fixed to the plantar border of the cavity of the phalanx, of which it seems a continuation; its posterior edge is free, or rather is loosely connected by some ligamentous fibres to the inequalities behind the head of the metatarsal bone, upon the contracted neck of which it is moulded very exactly, so that, while protecting the lower part of the joint, it serves also to increase the extent of the surfaces included in the articulation. 2. There are two very strong *lateral ligaments* (*y*, *figs.* 82 and 83.), an internal and an external, inserted not into the depressions on each side of the head of the metatarsal bone, but into tubercles situated behind them; from this origin they proceed very obliquely forwards and downwards, like flat bands, spreading out as they advance, and terminating partly in the inferior ligament, and partly on the sides of the phalanx. There is no dorsal ligament, properly so called, but the corresponding extensor tendon evidently occupies its place. It is not uncommon to observe a prolongation from the anterior surface of this tendon united to the metatarsal end of the first phalanx.

Synovial capsule. Under the extensor tendon we find a very loose *synovial capsule*; it covers the internal surface of the ligaments as well as the articular cartilages.

The *metatarso-phalangal articulation of the first metatarsal* bone presents some peculiarities which merit special description. 1. The articular surfaces are much larger than in the other similar joints. 2. The head of the first metatarsal bone presents two pullies on its plantar aspect, separated from each other by a prominent ridge directed from before backwards. This construction is connected with the presence of two sesamoid bones (*g*, *fig.* 84.), developed in the substance of the inferior ligament, which is three or four times thicker than in the other joints. The lateral ligaments are almost exclusively fixed into these sesamoid bones. This joint has also a sort of fibrous ring surmounting the border of the glenoid cavity of the phalanx.

Articulations of the Phalanges of the Toes.

These are perfect *angular ginglymi.* Each toe has two such joints, with the exception of the great toe, which has only one.

Articular surfaces. The anterior extremity of the first phalanx, flattened from above downwards, presents a trochlea, which is broader and prolonged further on the plantar than on the dorsal surface. On the second phalanx there are two small glenoid cavities separated by a ridge, the cavities corresponding to the small condyles, and the ridge to the groove of the trochlea just described.

Ligaments. 1. As the articular pulley of the first phalanx projects considerably below the second, it is covered in this direction by an *inferior* or *glenoid ligament* (*m*, *fig.* 82.), exactly resembling those of the metatarso-phalangal joints, and performing the same functions. 2. The two *lateral ligaments* (*y*, *figs.* 82 and 83.) are fixed precisely like the corresponding ligaments of the metatarso-phalangal joints, viz. into the tubercle above the lateral hollow on the anterior extremity of the first phalanx, and they extend obliquely forwards to the glenoid ligament and the second phalanx. 3. There is no *superior ligament*, its place being supplied by the extensor tendon. This tendon is arranged in a particular manner, for it frequently sends off a prolongation (*z*, *fig.* 83.) from its anterior surface, which is attached to the upper end of the second phalanx. 4. The *synovial capsule* is arranged as in the metatarso-phalangal articulations. There is often a sesamoid bone in the inferior ligament of the phalangal articulation of the great toe.

Mechanism of the Metatarso-phalangal Articulations.

all condyloid joints, these admit of movements in four principal di-, and therefore are also capable of circumduction. Extension or backwards can be carried much further than in any other similar The lateral movements of abduction and adduction are very limited. examine what takes place during each of these movements, in which noid cavity of the first phalanx glides upon the head of the corre-g metatarsal bone. In *flexion*, the first phalanx glides downwards upon l of the metatarsal bone; the extensor tendon and the upper part of ovial capsule, are stretched by the projecting head; the upper fibres of al ligaments are also stretched; these fibres then limit the motion, which eless may be carried so far that the phalanx may make a right angle e metatarsal bones. In *extension*, the phalanx glides upwards upon the the corresponding metatarsal bone; the superior fibres of the lateral ts are relaxed, whilst the inferior are stretched: these latter and the ligament evidently limit the motion.* In all subjects it may be carried s to make an obtuse angle behind; in some so as even to form a right The movements of *abduction* and *adduction* are limited by the meeting oes.

Mechanism of the Phalangal Articulations.

ie mechanism of these joints is in every respect identical with that of ers, we shall refer to what has been said upon that subject, merely re-g that, either from original construction, or from the continued confine-f the toes in tight shoes, their movements, which consist exclusively of and extension, are much more limited than those of the fingers.

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* *Arthrology.* [It has been considered advisable to include in a single note the following ons on the general anatomy of the several tissues that enter into the construction of the ons:—

ges (p. 148.). The substance of the *articular* cartilages, in many joints, appears to be in masses placed side by side, and perpendicularly to the surface of the bone, and hence us character presented by them after slight maceration: nevertheless, they are com-pure cartilage, unmixed with fibrous tissue. When viewed under the microscope, is found to consist of a transparent substance, in which are imbedded numerous cor-either placed singly, or aggregated in groups. The intermediate substance is homo-n youth, but becomes more or less laminated as age advances. The corpuscles, which ct, metamorphosed primitive cells, are of irregular forms, contain nuclei and nucleoli, somewhat flattened near the surface of the cartilage. Occasionally, several are seen g a distinct cavity in the intermediate substance. Their average size is $\frac{1}{1550}$th of an ength, by $\frac{1}{1330}$th in breadth. Neither nerves, bloodvessels, nor lymphatics, are found ticular cartilages; which, although non-vascular, can scarcely be considered unor-Cartilage contains 66 per cent. of water; its principal solid constituent is an animal esolved by boiling into a peculiar variety of gelatin, called chondrin: it also contains oda, lime, magnesia, and potash.

ter-articular cartilages having free surfaces (as those of the knee-joint), are composed artilage interwoven with fibrous tissue, which particularly abounds at their attached The inter-vertebral substances, and all other *interosseous cartilages*, have a similar , but contain a greater proportion of fibrous tissue. From the two anatomical elements these structures consist, they are called *fibro-cartilages*.

ticular borders surrounding the glenoid and cotyloid cavities, generally described with ents, are also composed of fibro-cartilaginous tissue.

nts (p. 149.). The *articular ligaments* consist entirely of fibrous tissue, the obvious st fibres of which are divisible into parallel microscopic filaments, exactly similar to cellular tissue (see note on APONEUROLOGY, *infrà*). They are supplied with but very ls and nerves; they contain 62 per cent. of water, the remainder being almost entirely l into gelatin by boiling.

llow elastic tissue, of which the ligamenta subflava are composed, differs in minute, as obvious characters, from the white fibrous tissue of ordinary ligaments. It consists peculiar filaments, intermixed with a few of those of cellular tissue. The proper aments, examined with the microscope, are yellowish and transparent, have a bright l dark outline (very unlike the delicate appearance of the cellular filaments), and are rved or bent at their torn extremities. The peculiar character of dividing and uniting

again, often assigned to them, is thought to be rather apparent than real, and to depend on an imperfect separation of the larger into their component filaments. The elastic is more vascular than the fibrous tissue. It contains less water (only 29 per cent.), and yields much less gelatin when boiled ; the insoluble residue somewhat resembles coagulated albumen.

Synovial membranes (p. 150.). The basis of an articular synovial membrane is cellular tissue, which becomes more and more condensed towards the free surface of the membrane. The smoothness of this surface is due to a covering of flattened scales (metamorphosed primitive cells) lying upon it, and constituting what is termed an epithelium. The recent discovery of this epithelium upon the surface of the articular cartilages, is sufficient to establish the continuity of the synovial membrane over them ; a fact which, though doubted by many, is assumed by M. Cruveilhier upon analogical grounds. No nerves have been traced into these membranes, and the vessels existing in the sub-synovial tissue cease at the margin of the cartilage. The synovia secreted by these membranes is an aqueous solution of albumen and saline matters. It contains more albumen than the fluid of serous cavities, the lining membranes of which (as we shall hereafter notice) have a similar structure to those just described.

Besides the *articular* synovial membranes, two other kinds are usually mentioned, viz. the *bursal*, including the various bursæ, erroneously called bursæ mucosæ, and the *vaginal*, examples of which are met with in the sheaths of tendons. These two forms will be again referred to in the note on APONEUROLOGY, *infrà*.

Adipose tissue. The constant occurrence, especially in the larger articulations, of masses of fat beneath the synovial membranes, affords an opportunity of alluding in this place to the minute anatomy of the *adipose tissue* generally. It may be briefly stated to consist of an aggregation of distinct spherical or oval vesicles, containing the adipose substance, and having numerous vessels ramifying on their transparent and homogeneous parietes. They are held together by the branches of those vessels, and by cellular tissue. In man, the adipose substance is liquid during life, but separates, when obtained in any quantity, into an oily fluid called elaine, and a solid residue, consisting of two fatty substances, stearine and margarine.]

ODONTOLOGY.

ıstances in which the teeth differ from bones. — Number. — Position. — ternal conformation. — General characters. — Classification — incisor — ine — molar. — Structure. — Development.

TEETH, the immediate instruments of mastication, are those ossiform conns, which surmount the edges and are implanted in the substance of both The teeth are not bones, though, from possessing an apparent analogy m, they have long been considered as such. They differ from bones in respects.

With regard to *position*. The teeth are naked and visible at the surface, ; the bones, and this is one of their most important characters, are covered riosteum.

In *anatomical characters*. The teeth consist of a bulb or thick papilla sur.ed by a calcareous envelope, composed of two substances, the enamel ıe ivory. This calcareous envelope is not traversed by vessels, nor can race of cellular tissue be discovered in it.

In regard to their *mode of developement*. In the teeth the formation of the or ossiform matter takes place by successive depositions, from the cir:rence to the centre; whilst bones are developed in a precisely opposite .ion. No nutritive changes are carried on in the teeth as in bones. Morethe teeth are renewed by means of the second dentition; but there is no gous phenomenon in the developement of bone.

In *physiological relations*. The teeth do not participate in the diseases of being susceptible only of chemical and physical alterations; nor is the l of their existence, like that of the bones, of equal duration with the life : individual.

In regard to *chemical composition*. They contain a much larger proportion ine matters, and the enamel is entirely destitute of gelatine.

l these circumstances prove that the teeth are not bones. We shall now that they belong to the epidermoid system, and are analogous to the nails ıair.

When examined in the lower animals, they are found to present an unin:pted series, from such as closely resemble horns or nails, to such as present ıost perfectly characteristic appearances of bone. 2. They have a lated structure, like the nails and hair: in some animals this is very manibut is rendered obscure in others from the abundance of calcareous de- 3. They are developed in the same manner as horns, nails, and hair. ːe them, they present no nutritive phenomena; they are formed layer after , and undergo no renewal of their constituent parts; they are* inorganic ;, the products of transudation. 5. According to M. Geoffroy St. Hilaire, :ak of birds, which is evidently a horny structure, belongs to the dental n.

mber. In young subjects, at the period of the first dentition, there are y teeth, ten in each jaw: in the adult there are thirty-two, sixteen in each Man, therefore, during the course of his life has fifty-two teeth, twenty ırary, and thirty-two permanent.

: varieties in the number of the teeth are either the result of a deficiency excess.

: varieties *from deficiency* consist, 1. in the absence of all teeth, examples ich have been recorded by Fox and Sabatier; 2. in the absence of a great er of teeth, as occurred in an individual who had only the four incisors h jaw. These deficiencies are chiefly observed to affect the posterior es, and frequently they are merely apparent in them, from the teeth reıg concealed within the alveoli for a much longer period than usual

* See note, p. 234.

Besides, Fox remarks, that there is no tooth which has not occasionally been observed to be wanting, either alone or in conjunction with others.

The varieties *from excess* are observed in the existence of *supernumerary teeth*, which may or may not range with the ordinary teeth. The supernumerary teeth either exist in distinct alveoli, or are blended with some other teeth. There are two varieties of this latter condition; for the supernumerary tooth may either appear to grow upon a primitive or parent tooth (*dens prolifer* of Bartholin), or several teeth may seem as if united into one.

Position. The teeth are arranged in two parabolic curves, constituting the dental arches, and corresponding to the alveolar arches which support them. Into these arches the teeth are fixed, not by articulation, but by the implantation of their roots into the alveoli, which are moulded exactly upon them. This arrangement induced those anatomists who regarded the teeth as true bones, to admit a peculiar mode of articulation for them called *gomphosis* (γόμφος, a nail).

The teeth are mechanically fixed in their alveoli; but yet we must consider the *gums*, and the *alveolo-dental periosteum* as also forming uniting media. The importance of the latter will be acknowledged, if we consider the effects of scurvy in loosening the teeth, and the ease with which they drop out from the skeleton.

Each dental arch forms a regular uninterrupted curve, an arrangement peculiar to man, for in the lower animals the teeth are of unequal length, and the dental arches have irregular edges; moreover, instead of their teeth being uninterruptedly contiguous, very considerable intervals, at some points at least, are left between them. Each dental arch presents an *anterior* convex, and a *posterior* concave surface; an *adherent* or alveolar border, which is regularly scalloped; and a *free edge*, thin and cutting at the middle, thick and tubercular at the sides; in the latter situations it has two lips, of which the external is sharper in the upper teeth, and the internal in the lower. The free edge is so arranged that all the teeth are upon a level.

As the superior dental arch forms a greater curve than the inferior, it necessarily follows that the two arches meet like the blades of a pair of scissors; but the mode in which they meet is not the same in the middle region, occupied by the incisor teeth, as on the sides where the molares are placed. Thus, the upper incisors pass in front of the lower, whilst the external tubercles of the superior molares pass to the outside of the external tubercles of the inferior molares, so that these latter tubercles are applied to the furrow formed between the two rows of tubercles of the upper molares.

The teeth of the upper jaw, with the exception of the great molares, are larger in general than those of the lower. I should also remark that no tooth is placed quite perpendicularly to its fellow in the other jaw; for the summit of a tooth in one jaw always corresponds to the interval between the summits of two in the other; so that the two rows of teeth are not simply in contact, but are really locked together.

External conformation. The teeth, considered in reference to their form or configuration, present some *general characters*, which distinguish them from all other organs of the body; and also certain *specific characters*, by which one tooth may be distinguished from another.

General characters (*figs.* 85 to 92.). Each tooth is composed of two very distinct parts; a free portion, projecting beyond the alveolus, named the *crown* or *body* (*a*, *figs.* 85, &c.), and a portion implanted in the bone called the *root* or *fang* (*b*), the constricted portion between these two constituting the *neck* (*c*). The rim of the alveolus or socket does not exactly correspond to the neck of the tooth, but rather to the root, at some distance from the neck, the intervening space being occupied by the gum.

The *axis* of the teeth is vertical. This direction is peculiar to the human species. The projection of the teeth forwards gives a disagreeable aspect to the countenance; and is almost invariably connected with a diminution of the

acial angle. The axis of all the teeth is slightly inclined, so as to converge omewhat towards the centre of the alveolar curve.

The *length* of the teeth (that is, of their crowns) is very nearly uniform. The dvantage of this arrangement in preventing one tooth from projecting beyond nother, is very obvious. When the teeth are not equal in length, mastication s evidently imperfect; and therefore the principal object, in cases of fracture f the lower jaw, is to prevent the inconvenience that would arise from irregularity of the dental edge, and which is actually observed when the fragments nite in a wrong position.

The teeth are only separated from each other by very small triangular ntervals, so that they are almost contiguous. When the intervals are very onsiderable, mastication is imperfect.

The *general form* of the teeth is that of a slightly elongated cone, flattened n opposite directions, the base of which is formed by the crown and turned owards the free edge of the dental arch, while the summit, formed by the imple or compound root, presents an opening that penetrates into the cavity f the tooth. The conical form of the root, and the accuracy with which the lveolus is moulded upon it, have a twofold result; viz. that the effort of nastication is disseminated over all points of the socket, and that no pressure s ever experienced at the extremity which receives the vessels and nerves.

The differences presented by the teeth, more especially in the crown, have ed to their arrangement into three classes; viz. *incisors*, *canine*, and *molars*: he latter have been subdivided into the *great* and *small molars*.

The crown of the *incisor* teeth (*figs.* 85, 86.) resembles a wedge with the sharp border shaped like a chisel; as their name implies, they serve the purpose of cutting the food. The crown of a *canine* tooth (*figs.* 87, 88.) forms a cone with a free pointed apex; these teeth serve to tear the food, whence their name of *laniaires:* Hunter called them *cuspidati*, from their having only one point. The crown of a *molar* tooth (*figs.* 89 to 92.) is cuboidal, the free extremity being provided with tubercles or points, intended to bruise the food as in a mill. The small molars, which have only two tubercles, are called by Hunter *bicuspides* (*figs.* 89 and 90.). Man alone, of the entire animal series, is possessed of the three kinds of teeth in an almost equal state of developement.

The Incisor Teeth (*figs.* 85 and 86.).

These are eight in number, four in either jaw. They occupy the middle of the dental arches, and consequently the anterior extremity of the lever of the third order, represented by each half of the jaw. Their position is unfavourable, and consequently they are intended only to divide substances that offer but little resistance. This class of teeth attain their utmost developement in rodentia; as in the rabbit, beaver, &c.

General characters. The *crown* (*a*) is wedge-shaped; its anterior surface (*fig.* 85.) is convex, and the posterior concave; its sides (*fig.* 86.) are triangular; its base is thick and continuous with the root, and its free edge sharp, somewhat broader than the base, and cut obliquely upwards and backwards in the upper teeth, and downwards and forwards in the lower. This obliquity of the surfaces by which the incisors of the two jaws correspond, is the result of their constant friction upon each other, for they cross like the blades of scissors. The cutting edge of an incisor tooth, before it is worn down, is marked by three small denticulations. The *root* (*b*) has the form of a cone flattened on the sides; the anterior border is thicker than the posterior. A small vertical furrow (see *fig.* 86.), occasionally exists on each side, appearing to indicate an *original* division; and sometimes the point of the root is bifid. Two curved lines, having their con-

Fig. 85.

Fig. 86.

cavities directed downwards, and united on the sides of the tooth, separate the root from the crown.*

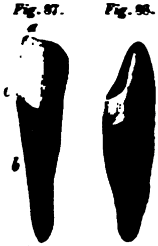
Differential characters. The *upper* incisors are distinguished from the *lower* by their much greater size, the former being almost twice as large as the latter. In the upper jaw, the *middle* are distinguished from the *lateral* incisors also by their well-marked superiority in size. In the lower jaw, on the contrary, the lateral incisors are the larger, though the difference is but slight.

The Canine Teeth (*figs.* 87, 88.).

These are *four* in number; *two* in each jaw. They are situated on either side externally to the incisors, and therefore are nearer to the fulcrum, so that they can overcome a greater resistance. These teeth are most completely developed in the carnivora. The tusks of the boar and of the elephant are also canine teeth.

General characters. They are the longest of all the teeth, both in the crown and in the root; they therefore project a little beyond the incisors, particularly in the upper jaw. Their *crown* (*a*) is thick and irregularly conoid; it is somewhat enlarged immediately above the neck, and terminates in a blunt point cut obliquely at the sides (see *fig.* 88.), and grooved behind. The anterior surface (*fig.* 87.) is convex, the posterior concave. The canine teeth have much longer and larger roots (*b*) than any other, and their alveoli are remarkably prominent. The root is flattened on the sides, each of which presents a vertical groove traversing its entire length (see *fig.* 88.).

Fig. 87. Fig. 88.



Differential characters. The superior canine teeth are distinguished from the inferior, by their greater length and thickness. The roots correspond to the ascending process of the superior maxilla, and in some subjects are prolonged to the base of that process. The length of their root explains the difficulty of extracting them, and the accidents by which this operation is sometimes followed. There are several preparations in the museum of the Faculty of Medicine, in which the canine teeth are seen developed in the substance of the ascending process, and reversed, so that the crown is turned upwards and the root downwards.

The Molar Teeth (*figs.* 89 to 92.).

The molar teeth are twenty in number; ten in each jaw. They occupy the last five alveoli on either side, and consequently are nearer to the fulcrum than all the other teeth: they are therefore most advantageously placed for exercising a powerful pressure upon any substances we may desire to break between the teeth. The instinctive motion by which, in order to crush a very hard body, we place it between the molars, is evidently connected with this arrangement. These teeth are most highly developed in herbivora.

The *general characters* which belong to all the molars, are the following:— 1. the great extent of their grinding surfaces, which far exceed those of the incisors and canine; 2. the absence of all obliquity at their summit, the anterior and posterior surfaces being parallel, instead of approaching each other, so as to form a cutting or angular border: this character is evidently connected with the preceding one; 3. the inequalities of their grinding surfaces, which are marked by eminences and depressions; 4. the round or even cubical form of the crown; 5. the shortness of the vertical diameter of the crown; 6. the multiplicity of roots.

* [It may be well to observe, that the illustrations are all taken from teeth of the upper jaw, in which the general characters of each class are more strongly marked than in those of the lower.]

The molars are divided into two classes, according to their difference in size, and the number of tubercles upon their grinding surfaces. The smaller are called *small molars* or *bicuspides;* the larger, *great molars,* or *multicuspides.* It should be remarked that in the first dentition, all the molars without exception are multicuspides.

The *small molars* or *bicuspides* (*figs.* 89 and 90.) are eight in number; four in each jaw, two on the right, and two on the left side. They are distinguished by the names first, second, &c. They are situated between the canine teeth and the great molars. The small molars of the upper jaw correspond to the canine fossæ.

General characters. The *crown* (*a*) is irregularly cylindrical, flattened from before backwards, with its long diameter directed transversely. The anterior and posterior surfaces, which correspond to the two neighbouring teeth, are plain (see *fig.* 90.). The internal and external (*fig.* 89.) surfaces are convex; the free or grinding surface is armed with two tubercles or points separated from each other by a furrow. Of the two tubercles the external is the larger. The crown of the small molars has been compared to that of two small canine teeth united. The *root* (*b*) is generally simple, but sometimes double or bifid. When simple, it has a deep vertical groove upon each side; when it is bifid, the separation is never so deep as in the great molars.

Fig. 89.

Fig. 90.

Differential characters. The lower bicuspides are distinguished from the upper by their smaller size, by a slight projection of the crown inwards, and by the external tubercle being worn down. In the upper bicuspides the two tubercles are separated by a deep furrow; in the lower, on the contrary, the furrow is more shallow, and the tubercles are sometimes united by a ridge. The second upper bicuspid has generally two roots (*figs.* 89 and 90.), by which it is distinguished from the others. The first lower bicuspid, somewhat smaller than the second, has most commonly but one tubercle, viz. the external. This gives it more resemblance to a canine tooth.

The *great molars* or *multicuspides* (*figs.* 91 and 92.) are twelve in number; six in each jaw, three on one side, and three on the other. They are named numerically, proceeding from before backwards, first, second, and third. The last is also called *dens sapientiæ,* on account of its tardy appearance. They occupy the most remote part of the alveolar border.

Fig. 91.

Fig. 92.

General characters. The *crown* (*a*) is pretty regularly cuboid. The anterior and posterior surfaces (see *fig.* 92.), by which these teeth correspond, are flat; the external and internal surfaces (*fig.* 91.) are rounded. The grinding surface is armed with four tubercles (*dentes quadricuspides*), separated by a crucial furrow, which is occasionally replaced by small depressions. In some teeth a fifth tubercle may be found. In almost all the tubercles are of unequal size, and cut into facettes. The crown of the great molars resembles two small molars united. The *root* (*b*) is always compound; it is most commonly double or triple, and, in this case, one of the roots has a longitudinal furrow. Sometimes it is divided into four or five parts, variable both in length and direction. The roots are either divergent or parallel; and occasionally, after separating, they approach each other again, curving like hooks, so as to embrace a more or less considerable portion of the jaw-bone. Such teeth (which are called *dents barrées*) it is impossible to extract, without pulling away the included portion of the jaw also. Each root of these teeth exactly resembles the single roots of the teeth already described, with the exception of being smaller.

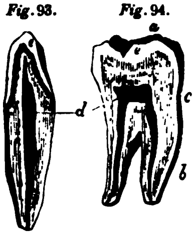
Differential characters of the upper compared with the lower molars. 1. Contrary to what was observed with regard to the other teeth, the crowns of the lower great molars are a little larger than those of the upper. 2. They are slightly bent inwards, while those of the upper great molars are quite vertical. 3. The lower great molars have only two roots, an anterior and a posterior. These roots are very strong and broad, flattened from before backwards, deeply grooved longitudinally, and bifurcated at the points. The upper great molars have, at least, three roots (*figs.* 91 and 92.), one internal and two external. It is very easy, then, to distinguish between the molar teeth of the two jaws.

Individual characters of the great molars. 1. The first great molar is distinguished from the other two by its size, in which it generally exceeds them. 2. The third great molar, or wisdom tooth, is distinguished from the first and second by its evidently smaller size; by its crown having only three tubercles, two external and one internal; by its shortness; and by its roots being, in certain cases, more or less completely joined together. However, even where the roots of these teeth are united, we always find the trace of the characters proper to the series of molar teeth to which they belong; *i. e.* the vestige of three roots, an internal and two external for the upper wisdom teeth, and of two roots, an anterior and a posterior for the lower

No teeth present so many varieties as the last molares which, occasionally, even remain buried in the substance of the maxillary tuberosity.

Structure of the Teeth.

Fig. 93. Fig. 94.



The crown of each tooth contains a cavity (*d*, *figs.* 93, 94.) corresponding with it in shape. This cavity is prolonged with contracted dimensions into the centre of the root, and opens by an orifice of variable size at the apex of the simple or compound cone, represented by the fang. The dimensions of this cavity are in an inverse proportion to the age of the tooth; so that it is largest at the earliest periods, but during the progress of years it becomes entirely obliterated. It contains a soft substance constituting the *dental pulp*. A tooth, therefore, is composed of two substances, an external *hard* or *cortical portion*, which is unorganised *, and an internal organised pulp.

The *dental pulp* contained in the cavity of the tooth as in a mould, has the same form as the tooth to which it belongs. This pulp is connected with the dental vessels and nerves by means of a nervous and vascular pedicle, which, after penetrating the dental cavity through the orifice in the apex of the root, and traversing the small canal, becomes continuous with it. From analogies, the accuracy of which will be seen in studying the developement of the teeth, the pulp may be regarded as a *bulb* or *large papilla*, and appears to consist of a nervous expansion traversed by a great number of vessels. Its arteries are derived from the internal maxillary; the nerves belong to the superior and inferior maxillary branches of the fifth pair. A membrane, rather difficult of demonstration on account of its tenuity, envelopes the pulp, which is extremely sensitive, is the seat of toothache, and to it alone must be referred all that has been said regarding the vitality and sensibility of the teeth.

The *hard* or *cortical portion* is composed of two substances, one of which covers the crown, and has been called the *enamel* (*e*, *figs.* 93 and 94.) from a comparison with the vitreous layer or glaze of porcelain; the other, constituting the entire root and the interior of the crown, is the *ivory* (*f*), improperly designated the *bony portion* of the tooth. The enamel is thickest on the

* See note, p. 234.

grinding surface of the tooth; it diminishes in thickness as it approaches the neck, at which part it terminates abruptly. The prominence of the curved line, indicating the termination of the enamel, gives rise to the constriction called the *neck*.

By comparing and in some degree contrasting the peculiar characters of the enamel and the ivory, we shall be better able to assign to each their respective properties.

1. The enamel is of a bluish-white, milky colour, and semi-transparent; the ivory is yellowish-white, and has an appearance like satin.

2. The enamel, examined in fragments of the crown, exhibits fibres perpendicularly implanted upon the ivory, and pressed closely to each other. The ivory, on the contrary, is formed of concentric layers*, the fibres of which are generally parallel to the long diameter of the tooth.

3. Both substances are excessively hard; but in this respect the enamel is superior to the ivory, for it will strike fire with steel, and is much less easily worn down by use; it can even turn the edge of a file. This excessive hardness, a principal element of immutability, explains how the teeth are preserved uninjured as long as the enamel remains entire, and, on the other hand, the facility with which they decay when once it has been removed. The great brittleness of the enamel, which is one of its most characteristic properties, is also owing to this extreme hardness.

4. In chemical composition, the enamel and ivory present important differences, indicated in the following tables: —

Ivory.		Enamel.	
Phosphate of lime - -	61·95	Phosphate of lime - - - -	85 3
Fluate of lime - - -	2·10	Fluate of lime - - -	3·2
Carbonate of lime - - -	5·30	Carbonate of lime - -	8·0
Phosphate of magnesia - -	1·25	Phosphate of magnesia - -	1·5
Soda and chloride of sodium -	1·40	Membranes, soda and water -	2·0
Cartilage and water - -	28·00		

It follows, therefore, that the principal chemical distinction between these substances depends on the existence of cartilage, that is, of an animal matter in the ivory, and on its absence in the enamel. The presence of cartilage in ivory forms a trace of resemblance between this substance and bone; and this is further strengthened by the result of the action of heat, by which both are similarly affected. Between the true bones and the ivory there is, however, all that difference by which a living tissue is distinguished from a solidified product of secretion. I admit, then, a complete want of vitality both in the ivory and the enamel of the tooth; nevertheless there are some phenomena which appear to contradict such an opinion.

1. The cortical substance of the tooth affords a much more perfect sensation of such bodies as come in contact with it, than either the nails or hair.

2. Weak acids, particularly vegetable acids, cause a peculiar sensation, when they are applied to the teeth, rendering the slightest touch extremely painful; a sensation generally expressed by saying that the teeth are set on edge.

But if, on the other hand, we reflect that the substance of the teeth is never affected by inflammation, that it never becomes the seat of any tumour or diseased product, and that it is worn away by rubbing and by the file, in the same way as an inorganic body, without any attempt at reparation or any evidence of the existence of a nutritive process, we must be led to admit the absence of vitality in these organs, and to explain the foregoing facts as dependent simply upon transmission.

Lastly, the hardness, fragility, and mutability of the enamel and ivory, vary in different individuals; hence the difference in the durability of the teeth, and their liability to change. It must not be imagined, that the ivory when exposed is susceptible of caries or necrosis; its changes are entirely of a che-

* See note, p. 234.

mical nature. The contrary opinion prevailed only so long as the teeth were considered true bones, and yet it has exercised an influence over the language of surgery which is not yet removed; thus, we are in the habit of speaking of a carious or necrosed tooth, and to describe them as affected with exostosis, and even with spina ventosa.

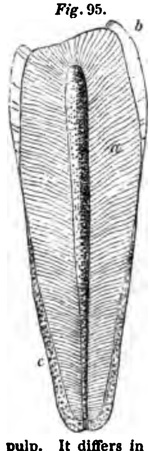
It follows, from all that has been said, that the human teeth are *simple*, *i. e.* formed by one centre of ivory covered with one layer of enamel. *Compound teeth* exist only in herbivora, in which animals mastication consists of a most extensive grinding movement; nor are they met with except among the molar teeth. The characteristic feature of a compound tooth is the division of the crown into a greater or smaller number of lesser crowns, each of which consists of a centre of ivory covered by a layer of enamel. All these crowns are united into one by a third substance, called the *cement* or *crusta petrosa*, of which the tartar of the human teeth will afford a sufficiently good idea.*

* [Recent researches into the structure of the teeth have brought so many interesting facts to light, that it is necessary to notice the result of these discoveries.

Three different structures at least enter into the formation of the human teeth, viz. the *ivory*, the *enamel*, and the *cortical substance*.

The *ivory* (*a*, *fig.* 95.) consists of a hard transparent substance, traversed by numerous tubes, about $\frac{1}{385}$th of a line in diameter, which commence by open orifices at the cavity of the pulp, and extend in an undulating but nearly parallel direction towards the surface of the ivory. In this course the tubes present secondary and smaller undulations, undergo a dichotomous division, diminish in size, at first gradually, then rapidly, give off numerous lateral twigs, and, finally, divide into extremely minute ramifications, of which some anastomose together, others communicate with small irregular dilatations called calcigerous cells, situated in the transparent intertubular substance, whilst the remainder appear to be lost at or near the surface of the ivory. The cells and tubes both contain calcareous matter, and seem to be analogous to the corpuscles of bone and the ramified lines radiating from them. In human teeth the cells are very minute; but in those of many animals they are much more distinct, and present a striking analogy to the osseous corpuscles.

Fig. 95.



The hard intertubular substance is not homogeneous, but, as may be clearly seen in young and growing teeth, is composed of fibres arranged parallel to the tubes, which appear to have distinct parietes. It consists of animal tissue, combined with a large amount of calcareous salts; and it is the seat of by far the greater proportion of the earthy matter contained in the *ivory* of the tooth.

The *enamel* (*b*, *fig.* 95.) is composed of hexagonal and transversely striated fibres, about $\frac{1}{460}$th of a line in diameter, arranged parallel to each other, and applied by their internal extremities to numerous corresponding depressions on the surface of the ivory, a delicate intervening membrane serving to connect the two structures. Near the neck of the tooth, the enamel fibres rest almost perpendicularly, near the apex of the crown, more or less obliquely upon the surface of the ivory; moreover they are often slightly waved or curved. Previously to the eruption of the tooth, each fibre contains an appreciable quantity of organic matter, which, at later periods, almost entirely disappears.

The *cortical substance* (*c*, *fig.* 95.) consists of a thin osseous layer developed on the external surface of the fangs, and, as life advances, extending even into their interior, and encroaching upon the cavity of the pulp. It differs in no essential particular from true bone, containing the characteristic corpuscles, and anastomosing tubuli of that tissue. It has been found also on the fangs of the teeth of most mammalia, and of a few reptiles and fishes; in some instances, direct communications have been discovered between the tubes of the ivory and the cells and tubuli of the cortical substance. The cement, or crusta petrosa, existing on the crowns of the compound teeth of the lower animals, also contains corpuscles and tubuli like those of bone, and may perhaps be regarded as an analogous deposit to the preceding, differing from it only in situation.

From a perusal of the preceding summary, it will be seen that not only has much additional knowledge been acquired regarding the structure of the teeth, but that many of the statements of M. Cruveilhier must now undergo considerable modification. Thus, 1. the crusta petrosa bears no resemblance to the tartar of the teeth, which is merely a deposit from the saliva. 2. Even simple teeth contain a third element in their structure, besides the ivory and enamel. 3. Instead of being inorganic bodies, the teeth are possessed of a complex organisation, which, we may add, is uniform throughout each species, and often sufficiently characteristic to be of the highest utility to the zoologist, &c. 4. A remarkable affinity has been established between the teeth and bone, as far as regards the structure of the cortical substance, and the ivory.]

DEVELOPEMENT OF THE TEETH, OR ODONTOGENY.

THE study of the developement of the teeth is one of the most interesting parts of their history. It embraces the description of the phenomena that precede, accompany, and follow the eruption of the first and second sets of teeth.

First, Temporary, or Provisional Teeth.

*Phenomena which precede their eruption.** If the jaws of a fœtus of two or three months be examined, it will be seen that they are marked by a broad

* [The earliest stage in the developement of the teeth, described in the text, is that in which the dental pulps are situated at the bottom of closed sacs; it has long been familiar to anatomists, and is now called the saccular stage. A condition antecedent to this, in which the future sacs are as yet open follicles, was first described by Arnold, but we are indebted to Mr. Goodsir (*Edin. Med. and Surg. Journ.* No. cxxxviii.) for the following connected history of the origin of the pulps and sacs of the temporary and permanent teeth:—

Origin of the pulps and sacs of the temporary teeth. In the upper jaw of a fœtus, about the sixth week, between the lip and a semicircular lobe constituting the early condition of the palate, is situated a depression of the form of a horse-shoe. During the seventh week, this begins to be divided by a ridge (commencing from behind) into two grooves, of which the outer forms the recess between the lip and the future external alveolar process, whilst the inner constitutes the *primitive dental groove*. The mucous membrane along the floor of this groove is then thickened, and from it a single papilla is developed, and subsequently four others arise from the external lip of the groove, in either half of the jaw. In the mean time, membranous laminæ projecting from the external lip, and at first only partially surrounding the papillæ, unite with similar but smaller processes from the internal lip, so that each papilla (*p*, 3, *fig.* 97.) becomes enclosed in a separate follicle (*f*, 3, *fig.* 97.), communicating with the cavity of the mouth and lined by its mucous membrane. The papillæ now increase in size, and gradually assuming the form of the future temporary teeth, sink within the yet open follicles. At this period, the edges of the latter appear to be developed into opercula (*o*, 4, *fig.* 97.), which differ in number and arrangement according to the shape of the crowns of the different teeth, there being two for the incisors, three for the canine, and four or five for the molars. The formation of the bony alveoli, by the developement of an external and internal alveolar process, and of inter-alveolar septa, closely follows the preceding changes in the soft parts.

The *order* and *time* of appearance of these ten papillæ in the upper jaw are as follow:—first, those of the *anterior* temporary *molars* during the seventh week; of the *canine* teeth at the eighth; of the *central*, and then of the *lateral incisors* about the ninth; and in the tenth week those of the *posterior molars*. The formation of the inter-follicular septa, and the other changes in the papillæ, follicles, and alveolar borders, described above, proceed in the same order, and are completed about the thirteenth week. The condition of the upper jaw at that period, constituting the end of the follicular stage in the developement of the temporary teeth, is seen in *fig.* 96., in which the follicles are shown as if held open; the diagrams 1 to 5 in *fig.* 97., representing perpendicular sections across the jaw, may serve to illustrate the successive changes in the mucous membrane, from the commencement of the groove to the completion of the follicles.

Fig. 96.

Fig. 96. *magnified three diameters.*

During the fourteenth week, a small crescentic *depression* (*c*, 5, *fig.* 97.) is formed immediately behind each of the follicles, the mouths of which are now closed by their opercula, but without adhesion; the lips of the groove, which at this time is called the *secondary dental groove*, are now applied to each other (6, *fig.* 97.). With the exception of the ten depressions just mentioned, and a small portion situated beyond the posterior temporary molar follicle, adhesion of every part of the groove now takes place, proceeding from before backwards. The follicles are thus converted by the fifteenth week into shut sacs (*s*, 7, *fig.* 97.), whilst the enlarged papillæ constitute the dental pulps (*p*, 7). The relation of the parts in this, the saccular, stage in the developement of the temporary teeth, is represented at 7, *fig.* 97.

Independently of a few subordinate differences, the changes in the lower jaw are similar, and occur in the same order, each step in the process being somewhat later than the corresponding one in the upper.

Origin of the pulps and sacs of the permanent teeth. It has been stated above, that, during the general adhesion of the dental groove occurring at the fifteenth week, the part posterior to the second temporary molar follicle (in either half of the jaw) still remains open; in this situation a papilla, sunk in an open follicle, appears during the sixteenth week. At the twentieth. the fundus of this follicle is converted into a sac, and the papilla into the pulp of the *anterior permanent molar* tooth, which is thus the earliest to appear of those of the second set, and is further characterised by being developed (like the papillæ of the temporary teeth) from the *primitive dental groove*, and on the same level with them. At the end of this week the hitherto open portion of the groove is entirely closed by adhesion of its lips, but its walls still remain dis-

and deep groove, divided by very thin septa into so many distinct sockets for the reception of the dental germs. The alveolar groove is closed at its free border by the *membrane* of the gum, which is stretched over a sort of thin, and, as it were, indented *crest*. This crest is formed by a tissue to which some anatomists have given the name of dental cartilage; it is a pale very strong fibrous tissue, and does not extend either upon the anterior or posterior surface of the bone, which are only covered by the mucous membrane, the gum being as yet confined to the alveolar border. The gingival fibrous tissue sends

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united, and a cavity is thus formed, situate between the sac of the anterior permanent molar and the surface of the gum: this is the *posterior cavity of reserve*, from which the pulps and sacs of the second and third molars are subsequently developed.

The ten depressions (*c*, 6) formed behind the follicles of the temporary teeth during the se-

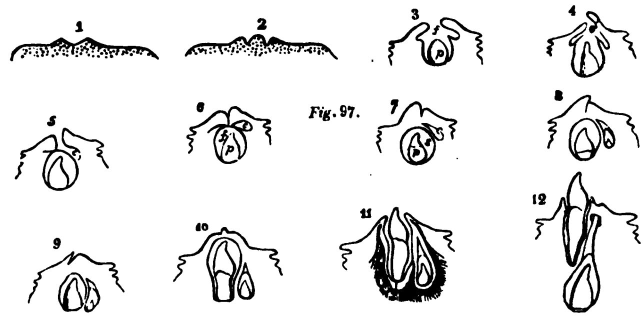

Fig. 97.

condary condition of the dental groove (6, *fig*. 97.), in consequence of their escaping the general adhesion of its lips and sides, are converted into as many cavities, called the *anterior cavities of reserve* (*c*, 7), which gradually elongate and recede into the substance of the gum. Pulps and folds (analogous to the opercula of the temporary follicles) are developed within them, appearing first in the anterior cavities; and they eventually become the sacs of the *ten anterior permanent teeth*, assuming a position behind and above those of the milk teeth in the upper, and behind and below them in the lower jaw (see 7 to 12, *fig*. 97.; also *fig*. 98. and *a*, *figs*. 101, 102.), each occupying corresponding recesses (*d*, *fig*. 102.) in the alveolar border.

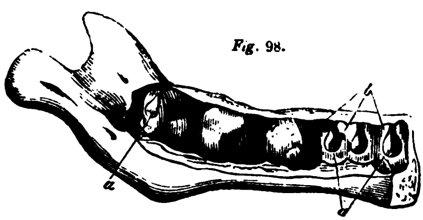

Fig. 98.

At this time, owing to the great relative increase in the size of the dental sacs, that of the anterior permanent molar (*a* 1, *fig*. 98.*) is forced backwards and upwards into the maxillary tuberosity of the upper, and into the coronoid process of the lower jaw (*a* 2); and the large posterior cavity of reserve (*b* 2) is drawn in the same direction. At birth, the length of the alveolar border increases relatively, and this sac again sinks to a level with those of the temporary teeth (*a* 3). The cavity of reserve (*b* 3), having now resumed its former position and shape, elongates backwards, and a pulp is developed in its fundus, which is converted before the fourth year into the sac of the *second permanent molar*. About the sixth or seventh year, the remaining part of the cavity once more elongates backwards, and forms the pulp and sac of the *third permanent molar*, or wisdom tooth. Each of these sacs undergo changes in their relative position in the jaws, similar to those experienced by the anterior permanent molar, at first receding backwards and upwards, and then descending behind and on a level with the sac immediately anterior to it.

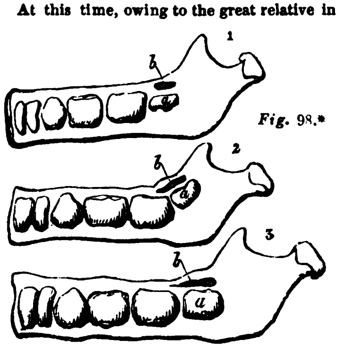

Fig. 98.*

a prolongation into each alveolus (*alveolo-dental periosteum*), that forms a fibro-mucous sac upon each follicle, perforated at the bottom of the socket for the passage of the dental vessels and nerves. As these prolongations or sacs are intimately connected to the gingival membrane, by pulling gently upon the latter we can raise the follicles from their receptacles, and completely lay bare the alveoli.

The *follicle* or *dental germ* consists essentially of a *membrane*, containing a sort of pediculated papilla, known as the *bulb* or *dental pulp*.

1. The *membrane* of the *follicle*, after having clothed the sac just described as lining the alveolus, is reflected upon the vessels and nerves which form the pedicle of the bulb, and appears to be prolonged upon the bulb itself: this, however, has not yet been demonstrated. The membrane of the follicle, therefore, resembles the serous membranes in forming a shut sac, the inner surface of which is free and smooth, and the outer adherent. A transparent viscid fluid occupies the space between the bulb and the alveolar portion of the membrane.

The following is the order in which the follicles of the first set of teeth appear. Towards the middle of the third month of fœtal life there are four distinct follicles in each jaw; at the end of the third month a third follicle appears in each half of the jaw, and a fourth and a fifth towards the end of the fourth month.

2. Of the *dental bulb*. In the earliest stages the membrane of the dental follicle only contains a fluid, which is at first reddish, and afterwards yellowish white; but towards the third month a small body makes its appearance, rising as a papilla from the bottom of the alveolus.* This papilla is abundantly supplied with vessels and nerves, and progressively increases in firmness and in size. A very thin pedicle, consisting of the dental vessels and nerves, affords attachment to it, so that it is suspended like a grape. This papilla, *dental bulb*, or pulp, gradually acquires the characteristic form of some particular tooth, of which it presents an exact model, constituting the nucleus around which the tooth itself is deposited. The first part developed upon this papilla is the crown of the tooth, on which we already find indications of the various eminences and depressions subsequently exhibited by it.

The developement of the hard portion commences towards the middle of pregnancy. The production of the ossiform matter upon the surface of the bulb is effected by a process of secretion †: it begins by the deposition of some small laminæ, or very delicate scales (1, *fig.* 99.) upon each projection of the pulp: they are at first pliable and elastic, but gradually become more consistent. These laminæ or scales constitute so many formative points for the tooth, and

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From the preceding observations it follows, that the pulps and sacs of both the temporary and permanent teeth have a common origin from the gastro-intestinal mucous membrane; that a *papilla* is first formed, afterwards surrounded by and sunk into a *follicle*, which latter is then converted into a closed *sac*; and hence the origin of the terms, *papillary*, *follicular*, and *saccular*, applied to these several conditions.

It moreover appears, that all the temporary teeth, and also the anterior permanent molar, originate from the *primitive dental groove*; and that all the permanent teeth, except the anterior molar, are developed from cavities of reserve commenced during its *secondary* condition.

For an account of the changes occurring in the pulps and sacs of the two sets of teeth, during the saccular and eruptive stages, the reader may now refer to the text; remembering, however, that the term *follicle* is there applied to the entire dental germ in its saccular condition, consisting of a closed sac and its contained pulp.]

* [The papilla of a temporary tooth appears even before the formation of the open follicle, and therefore long prior to its conversion into a shut sac. (See note, p. 235.)]

† [The *ivory* is no longer regarded, by the best authorities, as a *secretion* from the surface of the dental pulp, nor the *enamel* as a similar product from the parietal layer of the lining membrane of the sac. A microscopic examination of these two structures in their perfect condition is, indeed, alone sufficient to throw considerable doubt on the old opinion adopted in the text. The researches of Schwann into their mode of developement have again elucidated the subject. It has been observed that the globules in the centre of the dental pulp are primitive nucleated cells, analogous to those found in the early condition of all organic tissues; that at the surface of the pulp these cells assume a cylindrical form and a perpendicular arrangement, but still contain nuclei; that they adhere in places to the ossified scales, and correspond in size (not to the tubuli)

have been compared to the points of ossification in bones. The incisor and canine teeth have only one scale; the bicuspides have two; and the great molares as many as there are tubercles. These small scales so intimately embrace the pulp upon which they are moulded, that it requires some force to detach them; and yet their inner surface, as well as the outer, is very smooth. It should be remarked, that the pulp has a much more vividly red colour at the points covered by the scales. The scales are visible in the lower jaw at an earlier period than in the upper.

The following is the order in which they appear:—The middle incisors are visible from the fourth to the fifth month; they are soon followed, 1. by the lateral incisors; 2. by the first or anterior molar, which appears from the fifth to the sixth month; 3. at a short interval from each other, by the canine and the second molar; the scales of all the teeth of the first set have made their appearance by the seventh month, according to the observations of Meckel; but at the eighth month, according to Blake.

As developement advances the scales enlarge, and gradually uniting (2, *fig.* 99.) form a *sheath or shell of ivory*, which, during its growth, incloses the pulp, and, by degrees, extends to the vascular and nervous pedicle at the part where it penetrates the alveolus.* The outermost sheath being formed, a second is deposited within it, then a third within that, and so on. The external surface of the bulb secretes the ivory. The enamel is formed from the parietal or alveolar layer of the follicular membrane: at the commencement of its formation it is so soft that, in a fœtus at the full time, it can be very easily separated from the ivory. It has been asserted by some that the enamel, as well as the ivory, is the product of a secretion from the bulb, from which it has transuded in a liquid state through the different layers of the ivory, and has then solidified upon its surface; others affirm that the enamel is a sort of crystalline deposit from the fluid surrounding the tooth; but the greater number of anatomists admit, with Hunter, that the enamel is a product of secretion from the parietal layer †, as the ivory is from the layer of the follicular membrane, reflected upon the bulb. This opinion appears to me the more probable, because, on examining with attention the parietal layer, we find on its inner surface, near the crown of the tooth, a sort of pulp, or very evident enlargement, particularly in the follicles of the molar teeth. This external pulp becomes atrophied as soon as the

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but to the fibres of the inter-tubular substance in a growing tooth. From these facts Schwann concludes, that the formation of the *ivory*, like that of all other organised tissues, is effected by a metamorphosis of primitive nucleated cells; in other words, that it is developed by a progressive transformation and ossification of the superficial cells of the dental pulp — a theory which recent observations in this country would seem to have confirmed.

Similar evidence is advanced by him to prove that the *enamel* is formed in a similar manner from the pulpy enamel membrane, occupying the upper portion of the sac. The hexagonal fibres, of which the surface of this membrane consists, are, in fact, prismatic nucleated cells, resting perpendicularly on a tissue, in which are other cells of a vesicular form. The hexagonal fibres correspond, therefore, both in form and direction, with those of the perfect enamel; and, moreover, they are found to agree in size with the membranous remains of the enamel fibres of a growing tooth, after the removal of their earthy matter by means of a dilute acid.]

* [The vascular pulp of either a temporary or permanent tooth having more than one fang, is, after the formation of the crown, divided into as many processes by the advancement into it of the grey membrane of the sac. The dental substance still continuing to be produced on every part of the surface of the divided pulp, a bridge of ivory is thus formed across the area of the cavity of the tooth between each process (3 4, *fig.* 99.), around which separate fangs are subse-

Fig. 99.

quently developed (5, 6, 7), in the same manner as that around the undivided pulp of an incisor tooth.]

† See note, p. 237.

enamel is formed; and hence the fang is not covered with enamel, although, after the eruption of the tooth, that part occupies the former position of the crown. This external pulp does not exist in some of the dental follicles of certain animals, and we cannot, therefore, be astonished that such teeth have no enamel. Lastly, when this external pulp remains after the eruption of the teeth, the secretion of the enamel also continues, like that of the ivory. This is the case with the incisors of the rabbit and the beaver. In these animals the enamel occupies only the anterior surface of the tooth; consequently the edge always remains sharp, from the unequal wearing of the anterior and posterior surfaces.

From what has been said concerning the phenomena of the formation of the provisionary teeth before their eruption, we may draw the following conclusions: 1. Of the two constituent parts of a tooth, viz. the cortical or hard portion, and the medullary portion or pulp, the latter is first developed; and of the two distinct elements of the hard portion, viz. the ivory and the enamel, the formation of the ivory is first commenced. 2. The deposition of the cortical substance of the tooth begins at the crown; the roots are not formed until a subsequent period. 3. The bulb being inclosed within the solidified products which it has furnished, diminishes gradually in size as these press upon it.

Phenomena which accompany the eruption of the first or temporary teeth. At the time of birth all the teeth are still contained within their alveoli. Exceptions to this rule have been met with in cases where infants have been born with one or two teeth. If the anterior wall of the alveoli be removed at this time, the teeth will already be found considerably, but unequally developed, none having yet reached the bottom of the socket. But after birth, and at periods to be presently indicated, the extremity of the root having reached the bottom of the alveolus, and the further growth of the tooth in that direction being impossible, it is effected in the direction of the gum, which is compressed, becomes inflamed, and is perforated; this perforation, however, is not exclusively the result of distension, for the gum is but very slightly stretched when it opens; and in other cases where it is greatly distended, as by polypi or other tumours, it is not lacerated at all.

The tooth gradually rises, and the gum moulds itself successively upon the different portions of the crown, and, lastly, upon the neck of the tooth. The division of the gum is a severe process, but still it cannot altogether explain those serious symptoms which frequently accompany the first dentition.

The eruption of the teeth does not take place simultaneously, but in succession, and in a regular order that admits of but few exceptions. 1. The teeth of the same kind appear in pairs, one on the right side, the other on the left: 2. the teeth of the lower jaw precede those of the upper in their appearance*: 3. the middle incisors are cut before the lateral, these before the first molars; after these come the canine; and then the second molars. The eruption of the first set of teeth commences towards the sixth month after birth, and terminates at the end of the third or the commencement of the fourth year. The middle lower incisors appear from the fourth to the tenth month, and soon afterwards the upper middle incisors; the inferior lateral incisors appear from the eighth to the sixteenth month; and then the superior lateral incisors. The first lower molars are cut from the fifteenth to the twenty-fourth month; the lower canine from the twentieth to the thirtieth; and the upper first molars and canine soon afterwards. In some cases the eruption of the canine and the first molar teeth takes place simultaneously; sometimes even the canine teeth take the precedence. The second great molars appear from the twenty-eighth to the fortieth month. and thus complete the twenty teeth of the first set.

* [Although the papillæ, it will be remembered, appear *earlier* in the upper jaw.]

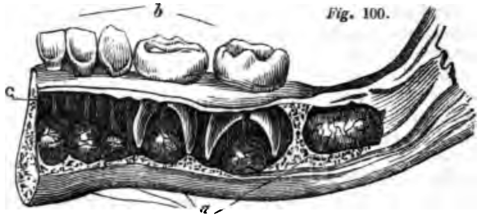
Second or Permanent Teeth.

*Phenomena which precede the eruption.** The second dentition consists of the eruption of the teeth called permanent, to distinguish them from the temporary teeth. They are thirty-two in number, so that there are twelve additional teeth in the second set. In this dentition, as in the former, we have to study the phenomena which precede, accompany, and follow the eruption of the teeth.

The follicles or germs of the second set of teeth correspond to the row of teeth already formed, bony septa intervening between them. They have the following relations with the follicles of the provisionary teeth. 1. The follicles of the additional teeth in the second set, viz. the three last molars, are situated in the same curve as the milk teeth, but they occupy of necessity the lateral extremities of these curves (*fig.* 100.). 2. The follicles of those teeth of the second set that replace others of the first, are, on the contrary, situated precisely behind the teeth to which they correspond (*a*, *figs.* 100, 101, 102.).

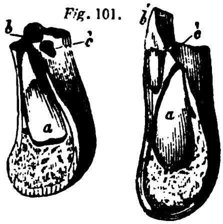
These follicles are at first contained in the same alveoli as the temporary teeth; but after a certain time septa are gradually formed between them, proceeding from the bottom of each alveolus towards its orifice (*figs.* 101, 102.). Nevertheless, for a long time after the formation of these septa, the temporary (*a*' *a*', *fig.* 102.) and the permanent ('*b* '*b*) alveoli communicate by tolerably large orifices (*c*' *c*', *figs.* 101, 102.), through which proceed the cords (*c*, *fig.* 102.) connecting the two teeth. The follicles of the permanent teeth do not sensibly differ in their mode of developement from those of the provisionary teeth, only the increase of the vascular system of the former coincides with the progressive atrophy of the vessels of the latter.

Fig. 100.



Phenomena which accompany their eruption. As long as the developement of the permanent teeth can be effected in a direction towards the bottom of their sockets, the temporary teeth remain uninjured; but when the growth of the permanent teeth influences their upper edges, the alveoli of the first set are compressed, and afterwards destroyed at the parts corresponding to the crowns of the permanent teeth (see *fig.* 101.). After this time the alveoli of the first and second sets form common cavities: the roots of the milk teeth being compressed by the crown of the permanent teeth, undergo a loss of substance, become loosened, and may be detached by the slightest effort, each tooth being retained in its place only by the sort of ring formed by the gum around its neck.

Fig. 101.



The shedding of the milk teeth is not always effected in the way we have described, viz. by a previous destruction of their root. Sometimes, in fact, the permanent tooth does not penetrate into the alveolus of the corresponding milk tooth; but this alveolus is gradually wasted away by the constantly increasing developement of the neighbouring permanent socket. In this case, the milk teeth may fall without destruction of their roots, which, however, are then almost always slender, and, as it were, atrophied. Some compression, either exercised upon the parietes of the temporary sockets, or upon the roots of the milk teeth, is almost indispensable for their expulsion. When, in fact, the permanent tooth deviates from its

* See note, p. 235.

natural direction, and consequently does not press upon the milk tooth, this latter remains, and forms a *supernumerary tooth*. We cannot, then, doubt the influence of this compression upon the fall of the milk teeth; but anatomists are not agreed as to the immediate cause of the destruction of the temporary alveoli, and of the roots of the teeth contained within them. How does this compression act? Does it produce the fall of the milk teeth in a purely mechanical manner, or does it effect this indirectly by the destruction of the dental vessels and nerves? One author believes the latter to be the principal cause; but what we have already said regarding the want of vitality in the teeth, will abundantly prove that the wearing away of the alveolus and the milk tooth is the result of mechanical pressure.

At the same time it should be observed, that, since the destruction of the roots of the milk teeth leaves no *débris*, a process of absorption must therefore be performed, the exciting cause of which is undoubtedly the compression above alluded to. It is not necessary, as some authors have believed, to assume the existence of a peculiar absorbent apparatus, appropriated to this office.

The teeth of the first dentition are shed in the space comprised between the sixth and the eighth year, the fall of each tooth taking place in the same order as its appearance. Blake was the first to point out the existence of a cord (*c*, *fig.* 102.) passing from the follicle of the permanent tooth, along a small long canal (*c′ c′*), behind the alveolus of the milk tooth, and becoming continuous with the gum. It has been supposed that the canal, and the cord placed within it, were intended to direct the tooth during the progress of its eruption. Hence the name of *iter dentis* given to the canal, and *gubernaculum dentis* applied to the cord, which has been ingeniously compared by M. Serres to the *gubernaculum testis*. This cord appears to me to be solid *, not hollow; it is very well marked in the incisor teeth, but forms a mere thread in the molars. Upon the whole, the influence exerted by the iter dentis and gubernaculum upon the direction of the permanent teeth during its eruption, is by no means constant.

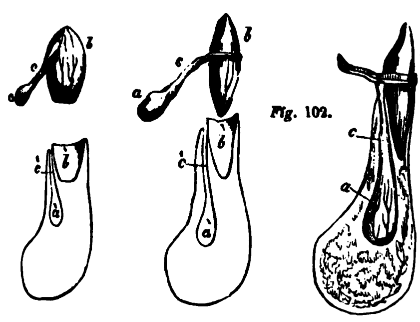


Fig. 102.

Order of eruption. The first permanent teeth which appear are the first great molars; they precede the other permanent teeth by a considerable interval, and immediately succeed the milk teeth, co-existing with them for some time; they have been, therefore, improperly classed among the first set of teeth in some anatomical treatises. The first great molars are known by the vulgar name of *seven years' teeth*. The eruption of the permanent teeth takes place in the same order as that of the milk teeth. Below are stated the *periods* at which each pair are protruded: —

Middle lower incisors	from	6	to	8	years.
Middle upper incisors	—	7	—	9	—
Lateral incisors	—	8	—	10	—
First small molar	—	9	—	11	—
Canine teeth	—	10	—	12	—
Second small molar	—	11	—	13	—
Second great molar	—	12	—	14	—
Third great molar	—	28	—	30	—

* [Arising from the adhesion of the sides of the elongated part of the cavity of reserve.]

The greatest irregularity exists in the eruption of this last molar tooth, which is often wanting, and frequently remains, during the whole of life, either partially or entirely inclosed within the substance of the jaw.

The incisor and canine teeth of the second set are much larger than the corresponding milk teeth. The opposite is the case with regard to the first two permanent molars, viz. the small molars, or bicuspides. It was ascertained by the inquiries of Hunter that, in this way, there is such a compensation, that the twenty teeth of the first set occupy precisely the same space as the twenty corresponding teeth of the second. This is not a purely speculative question, but one of singular interest in relation to the practice of extracting the milk teeth. The truth of Hunter's assertion may be confirmed by measuring with a thread the space occupied by the twenty temporary teeth, and comparing it with the space occupied by the corresponding teeth of the second set. M. Delabarre has done this upon the same individual at the period of the two dentitions.

Phenomena which follow the eruption of the permanent teeth. These relate, 1. to their growth; 2. to their decadence.

1. *Growth of the teeth.* The teeth of man are not like those of some animals, the rodentia in particular, susceptible of unlimited growth. The enamel of the crown wears away without ever being reproduced. All the facts brought forward in support of the idea of its reproduction, are either erroneous observations, or may be interpreted in a different manner. Nevertheless, some changes take place in the interior of the tooth which are worthy of notice. New layers of ivory continue to be secreted; and the cavity of the tooth is gradually encroached upon, and finally obliterated. Thus the teeth of the aged have neither pulp nor dental cavity.

2. *Decadence of the teeth.* The fall of the teeth in aged persons is the effect of a contraction of the alveoli produced in the following manner:—The teeth are dependances of the buccal mucous membrane, and are as it were only accidentally placed in the alveolar borders, which, from the tonicity or elasticity of their bony tissue, have a constant tendency to displace them. In one word, the tooth is to the alveolus like a foreign body of which it is incessantly tending to free itself. This tendency to contract on the part of the alveolus is effectually resisted, so long as the root of the tooth has a tendency to increase towards the bottom of the socket; but it acts with full force when this resistance ceases in consequence of atrophy of the pulp. Then the alveolus, shrinking upon itself, expels the tooth by a mechanism similar to that, by which during the progress of syphilitic affections, the most healthy looking teeth are displaced, solely in consequence of the vitality of the pulp being destroyed by the influence of the virus.

The fall of the teeth in the aged is regulated by no law, either as regards the time or the order in which it is effected.

Differences between the first and second sets of teeth. The teeth of the first dentition are distinguished from those of the second by the following characters:—1. Their colour, instead of being white, like ivory, or clear yellow, is of a bluish or azure white hue. 2. The temporary incisor and canine teeth are always distinguished from the corresponding permanent teeth by their smaller size and the shortness of their roots. 3. The two molars of the first set differ from the two small permanent molars or bicuspids which take their place, and approach nearer in character to the great molars; from these, however, they are distinguished by the shortness of their crowns, and by the number of tubercles on them, viz. five; three on the outside, and two on the inside. 4. Comparative chemical analyses of the teeth of the two sets have shown that the milk teeth contain somewhat less phosphate of lime than the permanent, and to this circumstance their greater susceptibility of change is due.

General observations. From the description we have given of the teeth, it will be seen that these organs should be looked upon merely as large vascular and nervous papillæ, covered by an unorganised calcareous sheath, which is

formed by a species of crystallisation.* The diseases of the teeth offer nothing incompatible with this theory, for, with the exception of toothache and the sensation of being set on edge, which are evidently seated in the pulp, the other alterations of which the teeth are susceptible, are either mechanical lesions, such as splitting, cracking, wearing, &c. or chemical changes, as the dry or moist caries, or, lastly, alterations appearing to have their seat in the hard substance of the tooth, but which are really situated elsewhere. Of this nature are the incrustations with tartar, the product of a vitiated secretion, attributed by several anatomists, and especially by M. Serres, to some small follicles, the function of which, before the eruption of the teeth, is to produce a fluid to soften the gum preparatory to its perforation by the teeth. Again exostosis and spina ventosa of the teeth evidently depend upon irregular secretion of the enamel and ivory. The consolidation of fractures of the teeth is explained by the formation of new layers resembling those which have been seen surrounding bullets in the substance of an elephant's tusk Lastly, the colouration of the teeth, from the action of madder, is only observed in the layers deposited during its use, and therefore does not prove the existence of any nutritive process in these organs, such as takes place in bone.

With regard to the evolution of the teeth in two distinct sets, it may be inquired what is the object of such an arrangement. Without entering here into the discussion of final causes, it cannot be denied that the second set of teeth would not accord with the comparatively small size of the jaws in the fœtus.

Use. 1. The teeth are the immediate agents of mastication. The incisors cut, the canine tear, and the molars grind the food; the position of each being regulated by the resistance they have to overcome. 2. The teeth form a kind of elevated border, which prevents the constant escape of saliva from the mouth. 3. They assist in rendering sounds articulate, by affording a fixed point to the tongue in the pronunciation of certain consonants, called by grammarians dental. 4. The teeth furnish important characters for zoological classifications. Indeed, as they bear a necessary relation to the mode of feeding in different animals, a circumstance that exercises so great an influence over their entire organisation, it may easily be conceived, that the form of the teeth is, to a certain extent, one of the characters by which a summary idea is conveyed of the nature of that organisation. At the same time, it is necessary to guard against the evidently erroneous conclusions, which some philosophers have delighted in deducing from the arrangement of the dental apparatus in man, with regard to his fitness for a purely animal, or exclusively vegetable diet. Above all it should be remembered, that the mechanical ingenuity of mankind must always form an indispensable element in the solution of every problem of this nature.

* [It is necessary in some degree to modify this definition of the hard portion of the teeth which, though *extra-vascular*, and, on that account, probably subject neither to interstitial absorption nor nutrition, cannot be regarded with propriety as *unorganised* or *crystalline* bodies.]

MYOLOGY.

The muscles in general. — Nomenclature. — Number. — Volume and substance.— Figure. — Dissection. — Relations. — Attachments. — Structure. — Uses.— Preparation. — Order of description.

THE active organs of locomotion are called *muscles.** They are composed of bundles of red or reddish fibres, consisting of fibrin as their *basis*, and possessing the essential property of *contractility*, that is, the power of contracting or shortening upon the application of a stimulus.†

Nomenclature of Muscles.

The names applied to the various muscles have not been founded upon uniform principle. Before the time of Sylvius the muscles of any region (of the thigh for example) were designated numerically, first, second, &c. in the order of their super-position or of their uses. Sylvius first gave particular names to the greater number of the muscles; and he was followed by almost all succeeding anatomists, especially by Riolanus. In this nomenclature, which is still generally adopted, the names of the muscles are derived, 1. from their situation, as radialis, ulnaris, peroneus, &c.; 2. from their size, as glutæus maximus, minimus; palmaris longus, brevis, &c.; 3. from their direction, as rectus abdominis, obliqui capitis; 4. from their shape, which is generally an imperfect representation, either of certain geometric figures, as rhomboideus, pyramidalis, and scalenus, or of well known objects, as deltoideus, lumbrici, and soleus (from *solea*, the sole fish); 5. from their divisions or complications, as digastricus (from having two bellies), triceps (from having three heads), biceps, complexus, &c.; 6. from their insertions, as sterno-hyoid, sterno-thyroid, &c.; 7. from their uses, as flexors, abductors, &c.

In modern times many attempts have been made to substitute in the place of these vague and generally arbitrary denominations, an uniform nomenclature, derived from the most important consideration, viz. the attachment of the muscles. The nomenclature of Chaussier, however, which is undoubtedly superior to all others, has not been adopted: first, because a knowledge of the old names cannot be neglected, since they are the only ones employed in a great number of works on medicine and surgery; and secondly, because even the most imperfect denominations, when they have been long in use, are, from this circumstance alone, preferable to any new appellations.

Number of the Muscles.

Upon this point likewise authors are but little agreed. According to most, the number of muscles is four hundred. Chaussier reduced it to three hundred. These differences arise partly from the fact, that the natural limits of the different muscles are not so well marked as those of the bones for example, and partly because the grounds of demarcation between the various muscles have not been sufficiently established. The following rules may be adopted with advantage: — 1. When a number of fasciculi unite, and form a mass, which is isolated both in its body and at its extremities, and fulfils distinct and determinate uses, such a collection should be considered a separate muscle. 2. A muscle should also be regarded as distinct, when it is separated from others at one portion only of its body, and at the most movable of its attachments. On the whole, whatever be the mode of demarcation adopted, it will

* From μυών, a muscle, or μυς, a mouse.

† It will be seen that, in constructing this definition, the only object has been to distinguish the muscles generally from other organs, by pointing out their two characteristic properties, viz. their fibrinous composition and their contractility.

be seen that the number of the muscles greatly exceeds that of the bones; the reason of this is, that each bone acts as a lever in a great variety of movements, whilst each muscle acts only in a very limited number of motions.

Volume and Substance of the Muscular System.

Of all the systems of organs in the body the muscular is predominant both in substance and in volume. This great mass of muscular apparatus is a necessary consequence of the unfavourable position of most of the levers represented by the bones. There is very great variety in different individuals, as regards both the volume and substance of the muscular system. Compare in this respect the glutæus maximus of a robust man, and the same muscle in a thin nervous individual, much emaciated, but yet in perfect health, for still greater differences are produced by disease: size and strength of the muscular system may also be natural or acquired, partial or general. Partial preponderance is most usually acquired, and is commonly the result of exercise. To be convinced of this, it is only necessary to inspect the muscles of certain regions, in individuals whose employment requires the special exercise of those parts. The preponderance of the muscles on the right side is produced solely by the habit of using this side more than the other; it is not, as has been alleged, the result of congenital difference.

Lastly, the size of one or the other region of the muscular system, in different animals, is in relation either with their instinctive propensities, their mode of feeding, or their natural attitude, or with some other important peculiarity in their organisation. Hence we find, 1. in the lion, the tiger, and other carnivorous animals that tear their prey in pieces, the muscles connected with the inferior maxilla, the most highly developed; 2. in the bear, which is a climbing animal, the muscles of the back; 3. in the hare, whose mode of progression is by successive leaps, the muscles of the hind limbs; 4. the muscles of the wing in birds; and 5. those of the lower extremities and the vertebral grooves in man, to whom the erect position is peculiar.

Figure of the Muscles.

The figure of the muscles is determined upon the following data:— 1. From a comparison of them with geometric figures or with familiar objects. 2. From the respective arrangement of their surfaces, edges, and angles; 3. from their being symmetrical or otherwise. In this latter respect there is a remarkable difference between the osseous and the muscular systems: many bones are symmetrical, or azygos, whilst almost all the muscles, on the contrary, are asymmetrical and arranged in pairs. 4. From the relative proportion between their three dimensions; from this latter consideration, muscles have been divided into three classes, viz. *long*, *broad*, and *short*, concerning each of which we shall make some general remarks.

The *long muscles* are chiefly met with in the limbs. Their length is sometimes considerable; and the longest are always most superficial. Very long muscles generally pass over several articulations, and can therefore assist in moving them all. This great length of certain muscles has also another advantage, viz. that it enables them to obtain a fixed point of attachment upon a less movable part, as the trunk, from which they can then act upon the more mobile parts: such is the case with the muscles that move the thigh or the leg. Long muscles are either simple or divided. Sometimes the division occurs at the more movable attachment; sometimes at that which is habitually fixed.

The *broad muscles* occupy the parietes of cavities; they are quadrilateral, when all their points of attachment are on the trunk; and triangular, when they extend from the trunk to the extremities. When several broad muscles are super-imposed, the fibres of one always cross those of another at an angle; and this arrangement by forming a sort of interweaving, greatly augments the

strength of the parietes which they assist in forming. This is particularly well shown in the broad muscles of the abdomen.

The *short muscles* are generally met with in the same situations as the short bones. It is not the shortness of its fibres, but of its fleshy body that characterises a short muscle. It is important to notice, with regard to these muscles, that a number of them are often arranged in succession so as to resemble a long muscle. Of this we shall find many examples in the muscles of the vertebral grooves.

Direction of the Muscles.

The *direction* of the muscles is one of the most important points in their history, since, without a knowledge of this, it is impossible to appreciate their uses. Each muscle has an *axis* or middle line, in which the general action of its fibres takes effect. Few muscles are altogether rectilinear; most are angular or curved; and almost all undergo certain deviations or reflections, in passing round the joints: some indeed take a direction, at right angles to their primitive course, when they pass over pulleys or hook-like processes. In muscles of this kind the action is in the direction of the reflected portion.

The direction of muscles must be studied with reference to the axis of the body, but especially to the axis of the limb or lever, *in relation to which they represent the moving power*. Many muscles are almost parallel to the axis of the lever upon which they act; but it should also be remarked, that in certain positions these same muscles form greater or smaller angles with their corresponding levers, and may even become perpendicular to them. In this respect the direction of the muscles is not absolute, but is subordinate to the position of the levers.

Some muscles are constantly perpendicular to the levers upon which they act.

The angles of incidence of the muscles upon their points of attachments are very variable, but generally they are more nearly parallel than perpendicular to those points. As the axis of a muscle is not the same as that of its component fibres, it is necessary to study, in each muscle, not only the direction of the fleshy belly but that of the fibres also.

Relations or Connections of the Muscles.

In reference to surgery, the relations or connections of the muscles are among the most important circumstances in their history.

Relations of the muscles to the skin. Those muscles only which are called cutaneous, are immediately connected with the skin; the remainder are separated from it by aponeuroses of greater or less density, so that the skin does not participate in the movements of the muscles, and *vice versâ*. Nevertheless, the changes produced in the form and size of the muscles during their contraction, are so decided, that those which lie near the surface are more or less defined through the integuments; but the projections corresponding to the bodies of the muscles and the depressions at their attachments, are in a measure obliterated by adipose tissue, the quantity of which varies in the two sexes and in different individuals. To this latter circumstance are due the differences in the outward characters of the muscular system of the female, as compared with the male; and of a fat individual, as compared with one who is emaciated.

Relations of the muscles to the bones. In the limbs where the muscles form several parallel layers around the bones, the belly or thickest part of the muscle always corresponds with the shaft or most slender portion of the bone; while the ends of the muscle, where it is thinnest, correspond with the expanded extremities of the bone. The relations of the bones with the muscles vary, according as the latter are deep-seated or superficial. The superficial

are only in contact with the bones by their extremities or their tendons: the deep-seated muscles alone correspond to the bones by their entire length.

Relations of the muscles to each other. The muscles are arranged upon each other in successive layers; each muscle is covered by a sort of fibro-cellular sheath; and a loose and moist cellular tissue is interposed between the different sheaths, so as to facilitate the gliding movement and independent contraction of each muscle. This isolation of the muscles does not exist throughout their entire length; several are often blended together in one common insertion, from which they proceed as from a centre, afterwards separating from each other. This community of attachment is principally observed in those muscles that perform analogous offices, or that, usually at least, act simultaneously. Most muscles are inclosed in a separate fibrous sheath, which isolates them in their actions and also in their diseases. Of this, we shall find remarkable examples in the rectus abdominis and sartorius. With regard to the relations of their edges, the muscles are sometimes contiguous throughout their entire course, and sometimes separated by intervals, generally of a triangular figure; and principally important in surgical anatomy, because incisions, for the exposure of vessels, are almost always made in such intervals.

Relations of muscles to the vessels and nerves. The muscles serve to protect the vessels and nerves, not only in consequence of the thickness of the layers which they form in front of them, but also by the resistance they oppose during their contraction to external violence. Near the centre of a limb there is generally a considerable cellular interval between the muscular layers, which is intended for the principal vessels and nerves. The existence of such spaces prevents the injury which these vital parts would sustain from compression during the contraction of the muscles. It is also worthy of notice, that whenever a vessel passes through the body of a muscle we find an aponeurotic arch or ring, which is non-contractile, and in some degree, therefore, obviates the danger of compression during the action of the muscular fibres. I say in some degree; because in order to render compression of the vessels impossible, the muscular fibres, attached to these rings, must have proceeded from them as from a centre, diverging in all directions. In this case the action of the muscles would not change the form of the rings, but would tend to increase their diameters in every direction. It is found, however, that they are invariably elongated in one direction and diminished in another, when the fibres of the muscle contract. Bernouilli, indeed, has shown that it is impossible to change the form of a circle, by making one of its diameters greater than the others, without, at the same time, diminishing its capacity; because, within a given periphery, the most regular figures have the greatest capacity, and the circle is more regular than either the oval or the ellipse. On the whole, however, it must be understood, that the contraction of the fibrous rings does not, in any material degree, impede the circulation.

It should also be remarked, that a distinct fibrous sheath surrounds the vessels and the nerves, serving to isolate and protect them amid the various muscles by which they are surrounded.

Most of the arteries have accompanying muscles, which may be called their respective satellites: thus, the sartorius is the satellite muscle of the femoral artery, the biceps of the brachial, the sterno-mastoid of the carotid, &c.

Attachments or Insertions of Muscles.

The *attachments* or *insertions* of muscles constitute one of the most important points in their history, and one which requires to be studied with the greatest care, because the uses of a muscle can be determined from a knowledge of its insertions alone. These insertions should be considered in two points of view: 1. as to the direct insertion of the muscular fibres into the tendons, aponeuroses, or other structures; 2. as to the insertion of the tendons and aponeuroses into the levers represented by the osseous system.

The *muscular fibres* themselves are attached, 1. to the *skin*, of which mode there are numerous examples in the muscles of the face; 2. to other muscular fibres, as in many muscles of the face and of the tongue; 3. to *cartilages*, as in several of the muscles of the chest and larynx; 4. to *aponeuroses*, of which they act as tensors, and whose power of resistance they thereby increase; lastly, to *tendons* or *aponeuroses* *, that are themselves attached to the bones.

The fleshy fibres are inserted into, or become continuous with the tendons and aponeuroses in the following manner:—the tendon is prolonged under the form of a membrane, either upon the surface or in the substance of the muscle. The results of this arrangement are, 1. an increase of surface for the attachment of the muscular fibres, which the tendon gathers up, as it were, in order to concentrate their efforts upon one point; 2. an obliquity in the insertion of the fibres, in reference to the axis of the entire muscle, by which the direction of the power is represented. It may easily be conceived, that this obliquity is of the greatest interest as regards the dynamic relations or active property of the muscles.†

One of the most curious circumstances respecting the continuity of a tendon or an aponeurosis with a muscle, is the very intimate union between the muscular and fibrous tissues, which is so complete that they are scarcely ever separated by external violence, which moreover tends to lacerate the muscle rather than the tendinous fibres.

It is a fact worthy of notice, and one which we have already had frequent occasion to remark, that the adhesion of any two organic tissues is stronger than the respective cohesion of each; so that the tissues themselves will sooner break than admit of separation from one another.

Insertion of the aponeuroses and tendons into the bones. A tendon or an aponeurosis forms a species of ligament, by means of which the action of a very large muscle is transmitted to the lever intended to be moved, by a fibrous cord or aponeurotic lamina of small size. A great advantage arises from this mode of economising the extent of bony surface required for muscular attachments. For, notwithstanding the extent of surface afforded by the expanded ends of the bones, and by the eminences and ridges with which they are covered, it would be evidently insufficient, were the muscular fibres to be directly attached.

The existence of tendons and aponeuroses produces also this remarkable result, viz. that the muscular insertions are much stronger than they would otherwise have been. The aponeurotic tissue acts as a *transition* structure, being in some points of its organisation analogous to bone, and in others approaching that of muscle. The analogy between the bony and fibrous tissues is confirmed by the frequent occurrence of ossification in the latter, even under normal conditions, as, may be observed in the formation of the sesamoid bones, and also in the mode by which tendons are attached. It has been observed, in fact, that at the point of junction of the tendons with the bones there is a sort of mutual fusion of the tissues, from which so intimate a connection results, that the proper substance of the tendons always give way before they can be separated from the bones, their attachments to which even maceration will scarcely destroy.

Of the different bones with which a muscle is connected some remain immovable during its contraction, whilst others are put in motion; hence the distinction between *fixed* and *movable* attachments. But this eminently useful distinction must not be taken in an absolute sense; it is only rigorously true of a very small number of muscles, which, like some of those found in the face, being connected by one extremity with the skin and by the other with the bones, can give rise to movements only at their cutaneous attachments.

* [The tendons afford examples of the fascicular form of fibrous tissue, for a notice of which see note, *infrà*.]

† In fact, as the tendon, and the aponeuroses by which it is continued into the muscle, represent the direction of the power, the fleshy fibres must necessarily be attached to it more or less obliquely. It is not our intention to examine here the great loss of power which this arrangement involves.

In the greater number of muscles, on the contrary, although one of the attachments is most commonly fixed and the other movable, yet their relative condition may be changed, and they may become alternately fixed and movable; it is therefore necessary, in explaining the action of a muscle, carefully to notice the supposed mobility or fixedness of the different attachments at the time.

In comparing such attachments as are habitually fixed with those that are constantly movable, we shall observe that the former are either numerous or spread out by means of aponeuroses, whereas the latter consist of very accurately circumscribed tendons. The figurative expressions of *head* and *tail*, given to the ends of a muscle, refer to this arrangement. The fixed attachment of a muscle is usually blended with those of several others, while the movable one is distinct.* In order to facilitate our description we shall invariably designate the fixed attachment of a muscle, its *origin*, and the movable attachment, its *termination* or *insertion*.

Structure of Muscles.

Muscles are composed of two kinds of fibres: 1. of *red* or *contractile fibres*, which form the muscular tissue properly so called; 2. of *white*, *strong*, and *non-contractile fibres*, constituting the tendons and aponeuroses. In speaking of the ligaments, we mentioned the general properties of tendons and aponeuroses as belonging to the fibrous tissues; we shall now make a few remarks on the peculiar characters of muscular tissue.

1. *Colour.* Muscular tissue is of a reddish colour, the intensity of which varies in different muscles and in different individuals. This colour is not an essential character even in the human subject, for the contractile fibres of the intestinal canal are very pale †; still less is it so in the lower animals, some of which have the entire muscular system perfectly colourless. The red colour of the muscular fibre is independent of the blood contained within the vessels of the muscle.

2. *Consistence.* The consistence of the muscular fibres varies in different subjects: in some it is soft and easily torn; in others it is firmer and more resisting, and retains for some time after death a degree of rigidity which yields with difficulty to forcible extension.

Structure. The muscles may be divided into bundles or fasciculi of different orders, and these again into distinct fibres, which are visible to the naked eye, and rendered more apparent, either by dissection, or by the action of alcohol, of diluted nitric acid, or even of boiling water. They are of a variable shape, resembling prisms of three, four, five, or six surfaces, but are never cylindrical. Their length also varies in different muscles, in but a few of which do they extend parallel to each other throughout the entire length of the fleshy belly.

Each muscle is surrounded by a sheath of cellular tissue, which also penetrates into its substance, and surrounds both the fasciculi and fibres. This cellular tissue permits the free motion of the different fasciculi upon one another, whilst it serves at the same time to isolate each and combine the whole.‡

The chemical analysis of muscular tissue shows that it is composed of a small quantity of free lactic acid (*Berzelius*); gelatin; some salts; osmazome

* [This assertion must be taken with some limitation. We shall find many exceptions to this general rule, as we proceed in the description of the muscles.]

† [The involuntary muscular tissue, of which the above-named fibres afford examples, are, with the exception of the heart, of a much paler colour than the voluntary muscles, to which this division of the present work exclusively refers.]

‡ [In reference to the microscopic structure of the voluntary muscles, or those of animal life, it has been ascertained that the smallest *fasciculi* (corresponding with the prismatic fibres of our author, and with the secondary fasciculi of Müller), the size of which varies in different muscles, are divisible into *transversely-striated fibres* (the primitive fasciculi of Müller), having a uniform diameter in all muscles in the same species, and being themselves composed of still

in greater or less quantity, according to the more or less advanced age of the individual; and leucine, a substance extracted from this tissue by the process described by M. Braconnot. (*Ann. de Chim. et de Phys.* tom. viii.)*

In addition to the tendinous and fleshy fibres, vessels, nerves, and cellular tissue also enter into the composition of muscles. We have already described the disposition of the cellular tissue *contained in these organs;* the mode of distribution of their vessels and nerves will be more appropriately alluded to in the description of the vascular and nervous systems.†

Uses of Muscles

The muscles are the active organs of motion, constituting the source of the power that is applied to the various levers represented by the component parts of the skeleton. The movements produced are the result of that peculiar property possessed by the muscles, of shortening themselves, which is called *muscular contractility (myotilité).* The shortening of a muscle is termed its *contraction,* and the opposite state its *relaxation.*

Phenomena of muscular contraction. During contraction the muscular fibres become folded in a zig-zag manner throughout their entire length; the muscle itself becomes hardened, and broader and thicker in proportion to the amount

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smaller elementary parts named *filaments* (the primitive fibres of Müller). All these elements of the muscular tissue extend parallel to each other, from one tendinous attachment to another, never having been seen to bifurcate or coalesce.

In man the *fibres* vary from $\frac{1}{400}$th to $\frac{1}{500}$th of an inch in diameter; the transverse striæ upon them are parallel, generally straight, but occasionally slightly waved or curved; they are situated at intervals of from $\frac{1}{15000}$th to $\frac{1}{12000}$th of an inch.

The *filaments* are varicose or beaded, *i. e.*, alternately enlarged and contracted; their diameter is from $\frac{1}{18000}$th to $\frac{1}{15000}$th of an inch. According to the general opinion, they are held together in each fibre by means of a glutinous substance, which latter, according to Skey, constitutes the entire centre of the fibre, the circumference alone being occupied by the filaments. In the larvæ of insects a delicate membranous sheath, sometimes observed projecting beyond the filaments, has been described by Schwann as forming a proper investment of the fibre; and by analogy this is also presumed to exist in man and the other vertebrata. Be this as it may, it is certain that the fibres have no separate sheaths of cellular tissue derived from the common sheath of the muscle, the prolongations of which appear to extend only so far as to enclose the smallest fasciculi.

The cause of the striated appearance has perhaps not been quite satisfactorily ascertained; but since the enlargements on the varicose filaments are darker than the constricted portions, and since they are situated at intervals precisely similar to those between the transverse striæ of the corresponding fibre, and from some other additional considerations, it has been supposed, with great probability, to result from the enlarged and dark portions of the filaments being arranged side by side.

For an account of the microscopic characters of the involuntary or organic muscular fibres, see the notes on the structure of the several viscera, &c. in which they are found, viz. the alimentary canal, trachea, genito-urinary organs, and iris. We may remark here, that the muscular fibres of the heart, and of the upper part of the œsophagus are striated, and approach very closely in character to those of animal life.]

* [The following analysis of the muscles of the ox is on the authority of Berzelius:—

Water	77·17
Fibrin (with vessels and nerves)	15·8
Cellular tissue convertible into gelatin	1·9
Albumen and colouring matter	2·2
Alcoholic extract, or osmazome, with lactic acid and lactates	1·8
Watery extract, with phosphate of soda	1·05
Phosphate of lime	·08
	100·

The inadvertent omission, on the part of M. Cruveilhier, of *fibrin* as one of the proximate principles of muscle, will serve to impress on the mind of the reader its importance as a constituent of that tissue, in which it exists in greater abundance than in any other.

The substance called leucine, mentioned in the text, is a *product* resulting from the action of concentrated sulphuric acid on muscular fibre, and therefore must not be regarded as previously existing in it.]

† As it is our intention to introduce, after Myology, an account of the Aponeuroses, we shall be content at present with the general ideas that have been already stated regarding this important division of the fibrous tissues.

of shortening. There is no oscillation in a muscular fibre during a normal contraction.*

The aponeuroses and the tendons take no part in the contraction: they are entirely passive. The degree of shortening, of which the muscular fibre is susceptible, cannot be precisely determined; as far as we know, the shortening, and consequently the extent of the resulting movement is proportional to the length of the fibre. A distinction should be drawn between the *force* and the *velocity* or rapidity of muscular contraction. Again, the velocity is very different from the extent of motion: the latter depends upon the length of the fibres; the former has no connection with it, but varies according to the constitution of the individual, and is probably dependent on a more or less rapid influx of nervous influence.

The *muscular force* is composed of a great number of elements. According to Borelli, an *intrinsic* and an *effective force* may be distinguished in each muscle. The intrinsic force is that power which the muscular fibres would exert if they were in the most favourable position for contraction; the effective force is measured by the result. The estimation of the force of a muscle presupposes a knowledge, 1. of the number of its fibres; 2. of their quality or constitution; 3. of the nature of the lever upon which it acts; 4. of the angle of incidence of the muscle upon that lever; and 5. of the angle of incidence of the fibres with respect to the imaginary axis of the muscle.

1. Each muscular fibre, being distinct from those around it, may be considered as a small power; it may therefore be easily conceived, that the greater the number of fibres in any muscle, the more energetic will be its contraction.

2. The quality and constitution of the fibre, and the intensity of the stimulus, have no less an influence upon the contractile force of a muscle than the number of its fibres. To be convinced of this, it is sufficient to compare the energy of movement in an individual excited by anger, with that in one who is calm.

3. The determination of the kind of lever †, represented by the bone upon

* The observations of Rogerus tend to show that rapid contractions and relaxations are *constantly* taking place in muscles, especially during their contraction. (Tr.) "De Perpetua Fibrarum Muscularium Palpitatione," 1760.

Fig. 103.

† A lever, in mechanics, signifies an inflexible rod capable of turning round a point. The point upon which the lever turns is called the *fulcrum* (*f*, *figs*. 103, 104, 105.); the cause of motion is called the *power* (*p*); and the obstacle to be surmounted is the *resistance* (*r*); the space between the fulcrum and the power is the *power-arm of the lever;* the space between the fulcrum and the weight, is the *resistance-arm of the lever*. There are three kinds of levers, distinguished by the respective arrangement of the three parts:—1. A *lever of the first order* (*fig*. 103.) has the fulcrum between the power and the resistance; 2. A *lever of the second order* (*fig*. 104.) has the resistance between the fulcrum and the power; 3. A *lever of the third order* (*fig*. 105.) has the power between the resistance and the fulcrum.

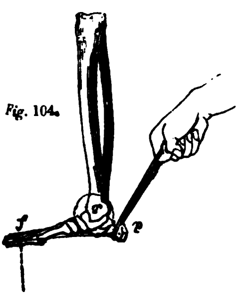
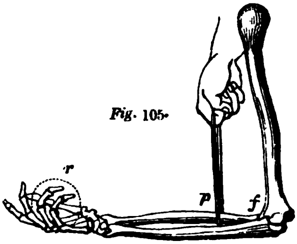
Fig. 104.


Fig. 105.


which the muscle acts, is a fundamental point in studying muscular action. It is a law in mechanics, that the power acts with greater effect, in proportion as its arm of the lever exceeds in length that of the resistance. The most common lever in the human body is that of the third order, in which the power being applied between the fulcrum and the weight, is therefore most disadvantageously situated for action.

4. As far as regards energy of movement the lever to which the power is applied is as unfavourable as possible, because the muscles are generally inserted near the fulcrum. But as a sort of compensation, an advantage peculiar to animal mechanics, the motions gain in velocity and extent what they lose in force, which, however, may still be obtained by an increase in the number of muscles, and of the fleshy fibres of each muscle. Nevertheless levers of the most favourable construction, and of the most advantageous position are met with in situations where considerable force is required; as in the articulation of the foot with the leg, presenting an example of a lever of the second order, and in the articulation of the head with the vertebral column, forming a lever of the first order.

The angle of *incidence* most favourable to the power, is the right angle; but in the human body, as the muscles are arranged in layers upon the bones which they are intended to move; they are for the most part inserted at very acute angles. Their incidence would be still more unfavourable, were it not for the enlargement of the articular extremities of the bones, which disturb the parallelism of the muscles. Besides, in certain cases, the angle of incidence more or less approaches or even attains to a right angle, and is combined with an extremely advantageous lever, when such an arrangement is required; as in the articulation of the foot with the leg.

It is of importance to notice, in determining the action of a muscle, that its incidence upon the bone varies at different periods during its action; so that a muscle, which is almost parallel to the lever, when it begins to contract, becomes perpendicular to it at a given moment during that process. It may be said that the *momentum of a muscle* occurs at that period of its action when its perpendicular incidence gives it the utmost energy of which it is capable: thus, the momentum of the action of the biceps femoris takes place when the leg forms a right angle with the thigh. In a certain number of muscles the momentum coincides with the commencement of action; such as the gastrocnemii and the solei. In some muscles the angle of incidence remains the same throughout the whole time of their action, and consequently they have no momentum: this is the case with the deltoid.

The angle of incidence of the muscular fibres, with regard to the imaginary axis of the muscle or the terminating tendon, involves a loss of power proportional to the amount of the angle. In some muscles the aponeuroses form a continuation of the fleshy fibres; in others, the angle of incidence of the muscular fibre is so acute that it may be left out of consideration.

Estimation of the action or uses of the muscles. Since the contraction of a muscle consists in its shortening, it follows that its action may be determined, *a priori*, from a knowledge merely of its attachments and direction. It may also be ascertained experimentally, by placing a limb in such a position that the muscle in question shall be perfectly relaxed. As the same muscle generally performs several uses, it is necessary to place the limb in several different positions, so as to determine those in which the muscle becomes relaxed. Let us take, for example, the glutæus maximus. If we desire to relax this muscle completely, it is necessary, 1. to extend the thigh upon the pelvis; 2. to abduct it; 3. to rotate it outwards: hence, it follows that the glutæus maximus is at once an extensor, an abductor, and a rotator outwards of the thigh. As a counterproof, the limb must be placed in such a condition that the muscle becomes completely stretched. The successive positions in which a muscle becomes stretched will be the very reverse of those which the limb assumes during the contraction of the muscle. Thus, the glutæus maximus is slightly

stretched by rotation inwards, more so by adduction, and most completely by flexion of the thigh upon the pelvis.

In determining the action of a muscle that is reflected over any angle of a bone, it is necessary to put out of consideration all that portion of the muscle intervening between its origin and its angle of reflection, and to suppose the power to operate directly from the latter points.

The action of sphincter muscles is to close the orifices around which they are placed. A curvilinear muscle assumes a rectilinear direction, at the very commencement of its action.

The insertions of a muscle are neither equally fixed, nor equally moveable. The *fixed point of a muscle* is that extremity which remains immoveable during contraction; but in certain cases the fixed may become *the moveable point:* this must be taken into consideration in determining the action of a muscle. The fixed point is most commonly that which is nearest to the trunk. But, with few exceptions, it is never completely stationary; and since a muscle would lose much of its power when acting between a moveable and an imperfectly fixed point, it is necessary that the latter should be kept as immoveable as possible by the contraction of other muscles. These consecutive contractions are often very extensive, and should be familiar both to the physician and the physiologist.

When a muscle passes over several articulations, it moves them all in succession, commencing with the one nearest to the moveable insertion.

Those muscles which concur in producing the same motion are called *congenerous;* those which execute opposite movements are termed *antagonists:* thus all the flexor muscles of any region are congenerous, and they are antagonists to the extensors.

Two muscles may be congenerous at one time, and act as antagonists at another: when they contract simultaneously, their individual and opposite effects are destroyed, and a common and intermediate effect results; thus when the flexor carpi ulnaris, which is both an adductor and a flexor, acts in conjunction with the extensor carpi ulnaris, which is an adductor and extensor, the hand is neither flexed nor extended, but is merely adducted. We shall constantly have occasion to notice this arrangement, which appears to me calculated to give much greater precision of motion, than if two perfectly congenerous muscles had been employed.

There are also certain compound motions, which are as it were the results of two different movements; thus, when the flexors and the adductors of the thigh act simultaneously, the femur passes in the intermediate direction. It is from this kind of combination that the movement of circumduction is produced by the action of the four orders of muscles situated at the extremities of the antero-posterior and transverse diameters of the joint. These four orders of muscles are known by the names of *flexors*, *extensors*, *adductors*, and *abductors*.

Lastly, muscles may contract without producing any motions, as when antagonist muscles act with equal energy. The result of such a simultaneous contraction is an *active immobility* or *tonic movement*, as the older writers termed it, which is of very great importance.

Preparation of Muscles.

Dissection. The end to be attained in the dissection of a muscle is to isolate it accurately from all the surrounding parts, leaving only those connections which are compatible with that object. Since, however, it is sometimes impossible to preserve the relations, and at the same time isolate the muscle, it then becomes necessary to be provided with two preparations for the demonstration or study of the same muscle.

In order to isolate a muscle, the surrounding cellular tissue, which often forms a very adherent sheath, must be removed; and to do this completely,

1. **Make a section of the skin parallel to the fibres of the muscle, deep** to reach the muscle through the sheath; 2. As soon as the flap of skin grasped by the hand, stretch and separate it from the muscle by cuttin the scalpel in the angle formed by these two parts. 3. When the sup surface is exposed, proceed to separate the deep surface, preserving a as possible all its important relations. 4. Then dissect the extremities, ing out their limits with the greatest care.

In the study of the muscular system, great importance should be a to the choice of subjects. Robust and tolerably fat subjects are best s for this purpose.

Preservation of muscles in liquids. Alcohol, oil of turpentine, a mix equal parts of these, or solutions of the bichloride of mercury, or pers of iron, may be employed for the preservation of muscles, though the many of their properties, such as their colour, consistence, &c.

Preparations by desiccation. As this kind of preparation requires a p method, we refer to the special treatises upon anatomical preparations account of them. (Vide *the works of MM. Marjolin and Louth.*)

Order of Description of the Muscles.

Before passing to the description of the particular muscles, it is ne to determine in what order they shall be studied. Galen divided th for this purpose into regions, and described the muscles of each in thei of super-imposition. In place of this arrangement which is purely to phical, Vesalius substituted a physiological one founded upon a consid of the uses of the muscles. This order was adopted by Winslow, who the different muscular regions in the following manner: — *Muscles whi the shoulder upon the trunk — muscles which move the arm upon the scapu* Albinus revived the method pursued by Galen, and divided the muscl forty-eight regions in the male, and forty-six in the female. He was f by Sabatier, and by Vicq-d'Azyr, who brought the arrangement to per by establishing some subdivisions in the groups formed by Albinus. modified, it has been adopted by most modern anatomists; it is evident ferable in many respects, since it is essentially anatomical, and is best lated to exhibit the relations of the different muscles and regions. In also to economy of subjects, and facility of dissection, it has many adv over the physiological order, with which however in many regions it made to coincide. We shall therefore adopt this arrangement, modi so far as to permit all the muscles to be dissected upon one subject; an having described all the muscles according to their topographical re we shall give a table in which they will be grouped in a physiological

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MUSCLES OF THE POSTERIOR REGION OF THE TRUNK.

The trapezius. — Latissimus dorsi and teres major. — Rhomboideus. — anguli scapulæ. — Serrati postici. — Splenius. — Posterior spinal mus Complexus. — Interspinalis colli. — Recti capitis postici, major et m Obliqui capitis, major et minor. — General view and action of the p spinal muscles.

The muscles situated on the posterior region of the trunk form layers, which proceeding from the skin to the bones consist on either the trapezius, the latissimus dorsi and teres major, the rhomboideus vator anguli scapulæ, the serrati postici superior et inferior, the sp the long muscles of the back, viz. the sacro-lumbalis and longissimus

* [The *transverso-spinalis* muscle includes the semi-spinalis colli, the semi-spinalis d *the* multifidus spinæ of Albinus.]

I regard as two series of accessory fasciculi to the longissimus dorsi), the complexus, the inter-spinales colli, the recti capitis postici major et minor and the obliqui capitis major et minor.

The Trapezius.

Dissection. 1. Render the muscle tense by placing a block under the chest; 2. Make an incision through the skin from the occipital protuberance to the twelfth dorsal vertebra, and another horizontally from the seventh cervical vertebra to the external end of the clavicle; 3. Reflect the two flaps, together with the cellular membrane adhering intimately to the muscle; 4. Dissect very carefully the insertions into the occipital bone which consist of a very thin aponeurosis closely united to the skin.

The *trapezius* (cucullaris, *Albinus*, *a*, *figs.* 106. 113.), the most superficial muscle on the posterior region of the trunk, covers the nape of the neck and the back. It is a broad triangular, rather than trapezoid muscle, thick in the middle, thin and elongated at its superior and inferior angles.

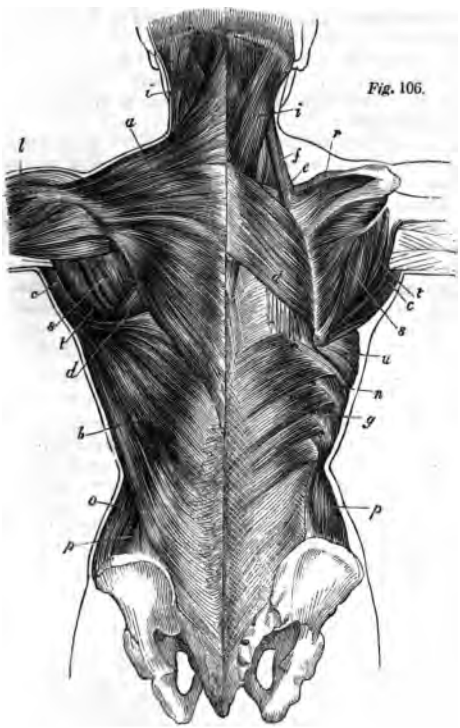


Fig. 106.

Attachments. It *arises* from the spinous processes of all the dorsal and the seventh cervical vertebra, from the corresponding supra-spinous ligaments, from the posterior cervical ligament (ligamentum nuchæ), and from the internal third of the superior occipital line, and is *inserted* into the entire length of the spine of the scapula, into the posterior border of the acromion, and into the external third of the posterior border of the clavicle. The fixed attachments or origins of this muscle present, 1. a broad, semi-elliptical aponeurosis, which when united to the one on the opposite side, forms an ellipse, occupying the space between the sixth cervical and the third dorsal vertebræ; 2. a very thin fibrous lamina, not having the ordinary shining appearance of an aponeurosis, which is firmly adherent to the skin, and forms the truncated occipital angle of the muscle; 3. a great number of tendinous fibres, constituting all those attachments to the vertebræ, that are independent of the two preceding aponeuroses. From these origins all the fleshy fibres proceed *outwards*, the inferior fibres from below upwards, the superior from above downwards, and from behind forwards, and the middle ones horizontally. They terminate in the following manner;— the

lower or ascending fibres are collected together, and attached to a triangular aponeurosis, which gliding over the small facette at the internal extremity of the spine of the scapula, is inserted into the tubercle immediately connected with it; the middle or horizontal fibres terminate at the posterior border of the spine of the scapula, by tendinous fibres which are very distinct, especially towards the acromion; the upper or descending fibres are inserted into the convex portion of the posterior border of the clavicle, many of them being also attached to the upper surface of that bone.

Relations. The trapezius is covered by the skin, from which it is separated by an aponeurotic lamina, except at the upper part, where the muscle and integuments are intimately adherent. It covers the complexus, splenius, rhomboideus, and levator anguli scapulæ, in the neck; and the serratus posticus superior, the supra-spinatus, the posterior spinal muscles, and the latissimus dorsi, in the back. The most important relations of this muscle are those of its superior and external or occipito-clavicular margin: this forms the posterior boundary of the supra-clavicular triangle, which is limited in front by the sterno-mastoid muscle, and below by the clavicle. It should be observed in reference to the indications regarding the supra-clavicular space, furnished by this margin of the trapezius, that it sometimes advances as far as the middle of the clavicle, and has even been observed to become blended with the posterior edge of the sterno-mastoid.

Action. 1. The upper or descending portion elevates the clavicle, and consequently the apex of the shoulder; but if the shoulder be fixed, this portion of the muscle inclines the head to one side and extends it, and moreover rotates it, so that the face is turned to the opposite side. 2. The middle or horizontal portion carries the shoulder backwards, but from the obliquity of the spine of the scapula, it also rotates that bone, so that the apex of the shoulder is carried upwards. 3. The lower or ascending portion draws the posterior costa of the scapula inwards and downwards; and by a species of rotation, which was alluded to when treating of the scapulo-clavicular articulations, also elevates the apex of the shoulder. 4. When the whole of the muscle contracts at once, the scapula is drawn inwards, and the apex of the shoulder is raised.

The Latissimus Dorsi and Teres Major.

Dissection. 1. Render the latissimus dorsi tense, by the same means as were employed for the trapezius, and also by withdrawing the arm from the side. 2. Make an incision in the median line from the tenth dorsal vertebra to the sacrum, and another transversely from the same vertebra to the posterior border of the axilla, dividing in the latter incision a fibro-cellular membrane, which adheres very firmly to the fleshy fibres. 3. Dissect the humeral insertion very carefully, and at the same time prepare the teres major, which is very intimately related to this extremity.

The Latissimus Dorsi.

The *latissimus dorsi* (*b*, *fig.* 106.; *p*, *figs.* 109, 110.) occupies the lumbar and part of the dorsal region, and the posterior border of the axilla. It is the broadest of all the muscles, and shaped like a triangle, having its inferior angle truncated, and its upper and external angles considerably elongated.

Attachments. It *arises* from the spinous processes of the last six or seven dorsal, of all the lumbar, and of the sacral vertebræ, from the posterior third of the crest of the ilium, and from the last four ribs, and is *inserted* into the bottom of the bicipital groove of the humerus, not into its posterior border.

Its origin from the crest of the ilium and from the vertebræ is effected through the medium of a triangular aponeurosis, narrow and thin above, broad and very strong below, where it is blended with the aponeuroses of the serratus posticus inferior and obliquus internus abdominis, and with the poste-

rior layer of the aponeurosis of the transversus abdominis. This aponeurosis assists in forming the sheath of the sacro-lumbalis, longissimus dorsi, and transverso-spinalis. The costal origins consist of fleshy tongues or digitations, which are interposed between similar processes of the external oblique. From this threefold origin the fleshy fibres proceed in the following manner: the upper pass horizontally, the middle are directed obliquely, and the lower vertically upwards; they all converge, so as to form a thick fasciculus, directed towards the inferior angle of the scapula, from which it often receives some accessory fibres. The muscle is then twisted upon itself, so that the inferior or vertical fibres become first anterior and then superior, while the superior or horizontal fibres become first posterior, and then inferior. This torsion may perhaps be intended to prevent displacement of the fibres. They all terminate in a flat quadrilateral tendon, which is inserted into the bottom of the bicipital groove, above the insertion of the tendon of the pectoralis major. This tendon furnishes a fibrous expansion continuous with the fascia of the arm, and also a band which extends to the lesser tuberosity of the humerus.

Relations. This muscle is covered by the skin (from which it is separated by a closely adherent fibro-cellular sheath), and by the inferior angle of the trapezius. It covers the posterior spinal muscles, the serratus posticus inferior, the external intercostals, the serratus magnus, the lower angle of the scapula, the rhomboideus, and lastly the teres major, by which muscle it is itself covered in its turn. Its external margin is in relation with the posterior border of the external oblique, from which it is separated below by a small triangular interval. The upper part of the external margin, together with the teres major, forms the posterior border of the axilla; and from the same margin a muscular fasciculus occasionally extends beneath the axilla to the lower edge of the pectoralis major.

The Teres Major.

This muscle (*c c*, *fig.* 106.) which both in its uses and its anatomical arrangements should be considered an accessory to the latissimus dorsi, is situated behind the shoulder.

Attachments. It *arises* from the quadrilateral surface, situated at the inferior angle of the scapula, to the outer side of the infra-spinous fossa, and is inserted into the posterior border of the bicipital groove. The scapular attachment consists of short tendinous fibres, some of which are fixed directly to the bone, and some into the fasciæ, which separate this muscle from those of the infra-spinous and subscapular fossæ. The fleshy fibres arising from these different attachments form a thick fasciculus, flattened from before backwards, not cylindrical, and about two or three fingers in breadth, which is *directed* outwards and upwards, and becomes slightly twisted, so as to be inserted by a broad and flat tendon into the posterior border of the bicipital groove.

Relations. The latissimus dorsi at first covers its scapular extremity, and then turning round its lower edge becomes anterior to it. The tendon of the latissimus dorsi is therefore applied to the anterior surface of the tendon of the teres major: but since the former is attached to the bottom, and sometimes even to the anterior border of the bicipital groove, and the latter to the posterior border of the same groove, they are separated at their insertions by an interval, in which there is almost always a synovial membrane, and which forms a true cul-de-sac below, for the lower margins of the two tendons are blended together.

The posterior surface of the teres major is covered by the skin, from which it is separated on the inside by the latissimus dorsi, and externally by the long head of the triceps. Its anterior surface is in relation with the subscapularis, the coraco-brachialis, the short head of the biceps, the brachial plexus, the axillary vessels, and the cellular tissue of the axilla. Its upper margin is at first in contact with the teres minor, from which i is separated above by the long

head of the triceps; its lower margin forms in conjunction with the latissimus dorsi the posterior border of the axilla.

Action of the latissimus dorsi and teres major. The latissimus dorsi adducts the arm, rotates it inwards, and at the same time draws it backwards (hence its name, *ani scalptor*). When only the upper or horizontal fibres contract, the arm is carried inwards and backwards; when the lower fibres act alone, it is carried downwards.

The uses of the teres major are precisely similar to those of the latissimus dorsi, to which it is congenerous and accessory, and with which it is always associated in action, drawing the humerus inwards, backwards, and downwards. When the humerus is the fixed point, the latissimus dorsi raises the trunk, and with the greater facility, because it is attached to the ribs, the spine, and the pelvis. In consequence of its costal attachments, the latissimus dorsi is a muscle of inspiration; and it should be observed, that the direction of its fibres, which is almost perpendicular to the ribs, enables it to act with great power.

The Rhomboideus.

Dissection. Divide the trapezius by an incision extending from the third dorsal vertebra to the lower angle of the scapula; dissect back the flaps, taking care to remove a fibro-cellular layer, which adheres closely to the trapezius.

The *rhomboideus* (*d d*, *fig.* 106.) situated in the dorsal region, on the posterior aspect of the trunk, approaches closely to the form of a rhomboid or lozenge; it is broad and thin, but thicker below than above, and is almost always divided into two parts.

Attachments. It *arises* from the bottom of the ligamentum nuchæ, from the spinous processes of the seventh cervical and five superior dorsal vertebræ and from the corresponding interspinous ligaments, and is *inserted* into all that part of the posterior costa of the scapula, situated below its spine. The *spinal* or internal attachments consist of tendinous fibres, the most inferior of which are the longest. From these points the fleshy fibres proceed, parallel to each other, downwards and outwards, to a very thin tendon, which runs along the posterior costa of the scapula, but only adheres to it above and below: the greater number of fibres are inserted into the lower angle of the scapula by a very strong tendon, which forms the principal attachment of the muscle, and to which the tendon mentioned above is merely subordinate. The upper part of this muscle (*e*, *fig.* 103.), which arises from the ligamentum nuchæ and the seventh cervical vertebra, is inserted by itself opposite the spine of the scapula. It is distinct from the remainder of the muscle, and from this fact Vesalius, Albinus, and Sœmmering, gave it the name of *rhomboideus minor* or *superior*.

Relations. This muscle is covered by the trapezius, the latissimus dorsi, and the skin. It covers the serratus posticus superior, part of the posterior spinal muscles, the ribs, and the intercostal muscles.

Action. The rhomboid raises the scapula and draws it inwards. As it acts principally upon the lower angle of that bone, it rotates it in such a manner, that the anterior angle, and consequently the apex of the shoulder, is depressed. It assists the trapezius in carrying the entire shoulder inwards, and is also associated with the upper fibres of the same muscle in raising that part; but, on the other hand, it antagonises the trapezius, by depressing the apex of the shoulder.

The Levator Anguli Scapulæ.

Dissection. Detach the trapezius from the spine of the scapula with care; divide the upper part of the sterno-mastoid, so as to expose the transverse processes of the three or four superior cervical vertebræ.

The *levator anguli scapulæ* (levator scapulæ, *Albinus*, *f*, *figs.* 106. 110. 113.

114.), *situated* at the posterior and lateral part of the neck, is an elongated bundle, having its upper portion flattened from without inwards, and divided into three or four fasciculi, whilst the lower part is flattened from behind forwards.

Attachments. It *arises* from the posterior tubercles of the transverse processes of the three or four superior cervical vertebræ, externally to the splenius, and behind the scalenus posticus; it is *inserted* into the superior angle of the scapula (whence its name), and into all that portion of its internal costa situated above the spine.

The cervical attachments of this muscle consist of four tendons, to which succeed an equal number of fleshy fasciculi, at first distinct, but afterwards united into one bundle, which proceeds downwards, backwards, and outwards, and spreads out to be inserted into the scapula by short aponeurotic fibres.

Relations. It is covered by the trapezius, the sterno-mastoid, and the skin; and it lies superficially to the splenius, the sacro-lumbalis, the transversalis colli, and the serratus posticus superior.

Action. When its upper attachment is fixed, this muscle carries the posterior angle of the scapula upwards and forwards, and consequently rotates that bone so as to depress the apex of the shoulder. It conspires with the rhomboid and the trapezius in elevating the entire shoulder, and with the rhomboid in depressing its apex, in this respect acting as an antagonist to the trapezius. When the fixed point is below, which must be very rarely, it inclines the neck backwards and to its own side.

The Serrati Postici.

These are two in number, a superior and an inferior.

Dissection. 1. To expose the *superior* muscle, divide and reflect the trapezius and the rhomboid, and draw the scapula forwards; — 2. To display the *inferior*, raise the latissimus dorsi with great care, as its deep aponeurosis is blended with that of the serratus posticus inferior; — 3. Preserve the thin aponeurosis extending between the two serrati muscles.*

1. The *serratus posticus superior* is *situated* at the upper and back part of the thorax, and is of an irregularly quadrilateral figure.

Attachments. It *arises* from the ligamentum nuchæ and the spinous processes of the seventh cervical and of the two or three upper dorsal vertebræ, and is *inserted* into the upper borders of the second, third, fourth, and fifth ribs. The vertebral attachment consists of a very thin aponeurosis, the fibres of which are parallel and inclined downwards and outwards. From this aponeurosis, which constitutes at least the inner half of the muscle, the fleshy fibres proceed in the same direction, and almost immediately divide into four digitations, which are inserted into the ribs by means of short tendinous fibres. The superior digitation is attached near the angle of the corresponding rib, and each of the others at successively greater distances from it.

2. The *serratus posticus inferior* (lumbo-costalis, *Chaussier*, *g*, *fig.* 106.) is also of an irregularly quadrilateral form, and is situated at the lower part of the back, and the upper part of the loins. It *arises* from the spinous processes of the two lower dorsal and three upper lumbar vertebræ, and is *inserted* into the inferior borders of the last four ribs. The vertebral or internal attachment consists of an aponeurosis similar to that of the preceding muscle, but its fibres have an inverse direction, *i. e.* obliquely outwards and upwards. From this aponeurosis, which forms the internal half of the muscle, the fleshy fibres proceed in the same direction, and divide into four flat digitations, progressively decreasing in size from above downwards, which are inserted into the ribs by means of tendinous laminæ, the superior digitation near the angle of its corresponding rib, and the others successively further beyond it.

* [This exceedingly thin and semitransparent lamella has received the name of the *vertebral aponeurosis*. See APONEUROLOGY.]

Relations. These two muscles have certain relations in common, and there are some peculiar to each. They both cover the longissimus dorsi, the sacrolumbalis, the transverso-spinalis, the ribs, and the corresponding intercostal muscles. The superior is covered by the rhomboideus, the trapezius, and the serratus magnus, and covers the splenius and transversalis colli. The inferior is covered by the latissimus dorsi, with the aponeurosis of which muscle its own aponeurotic lamina is so closely united, that it is impossible to separate them completely; and it covers the posterior layer of the aponeurosis of the transversalis.

Action. Besides certain common uses, each muscle has its own peculiar action. One important common use is to retain in the vertebral groove those muscles of the back, which from their extreme length are the most liable to displacement. This effect is produced by their fleshy portions rendering tense their aponeurotic expansions.

With regard to the actions proper to each, 1. the superior elevates those ribs into which it is inserted, and is consequently a muscle of inspiration; 2. the inferior, on the other hand, is a depressor of the ribs, and therefore a muscle of expiration.

The Splenius.

Dissection. Merely remove the trapezius, the rhomboid, and the serratus posticus superior.

The *splenius* (*i, figs.* 106. 113, 114.), so named because it has been compared to the spleen (σπλὴν), is *situated* at the posterior part of the neck, and upper part of the back. It is a broad muscle, terminating in a point below, and dividing into two portions above.

Attachments. It *arises* from the spinous processes of the four or five superior dorsal and the seventh cervical vertebræ, from the corresponding supraspinous ligaments, and also from the ligamentum nuchæ, between the seventh and the third cervical vertebræ: it is *inserted*, 1. into the transverse processes of the first, second, and often of the third cervical vertebræ; 2. into the external surface and posterior border of the mastoid process, and the external third of the rough space beneath the superior semi-circular line of the occipital bone. The spinal attachments consist of tendinous fibres, the most inferior of which are the longest. From these the fleshy fibres proceed obliquely upwards and outwards, the lower being longer and more vertical, and form a broad flat muscle, which is much thicker externally, and soon becomes divided into two portions — one smaller, inferior and external, the other much larger, superior and internal. The former is called the splenius colli: it is sometimes distinct, even from its origin, and soon subdivides into two or three fasciculi, which terminate in as many tendinous processes, that are inserted into the atlas, the axis, and often into the third cervical vertebra. The fasciculus proceeding to the atlas is usually the largest. The second, or the upper and internal portion of the muscle, is connected with the head, and is called the *splenius capitis.*

Relations. The splenius is covered by the trapezius (the rhomboid and the serratus posticus superior intervening below), by the sterno-mastoid, and by the levator anguli scapulæ. It covers the complexus, the longissimus dorsi, the transversalis colli, and the trachelo-mastoid. The levator anguli scapulæ is in contact with its outer border, and rests upon it above, the cervical insertions of the two muscles being blended together; below they are separated by the transversalis colli and sacro-lumbalis. The internal edge is very thin, and separated from the muscle of the opposite side by a triangular interval in which the complexi are visible.

Actions. The splenius extends the head, inclines it to its own side, and rotates it so that the face is turned to the same side. This action of the splenius depends on its attachments to the occipital bone, the mastoid process, and the

atlas. By its insertions into the second and third cervical vertebræ it tends to rotate these in the same direction. When the two muscles act together, the head is drawn directly backwards. The splenius is therefore an *extensor* and *rotator* of the head and of the neck; it assists in supporting the head in the erect position, and prevents it from inclining forwards in obedience to the force of gravity.

The Posterior Spinal Muscles.

As these muscles are arranged in a peculiar manner, we shall adopt a method of description in some measure different from that which we have elsewhere employed.

The posterior spinal or long muscles of the back (see *fig.* 107.) are three in number, viz. the *sacro-lumbalis*, the *longissimus dorsi*, and the *transverso-spinalis muscle.*

These three muscles, which extend the entire length of the spine, form a very large muscular mass, completely filling up the corresponding vertebral groove. This mass is small at the lower part of the sacral groove, becomes much enlarged in the loins, then diminishes in the back, and again acquires a considerable size in the neck. Chaussier has given a description of them under the collective name of the *sacro-spinal* muscle; and they have also been denominated the *erector spinæ.*

I shall describe the three muscles together; but in order to adopt some arrangement in a matter so complicated, I shall divide them into three portions, viz. a lumbo-sacral, a thoracic, and a cervical.

Lumbo-sacral Portion of the Posterior Spinal Muscles.

Dissection. 1. Render this portion of the muscle tense, by placing a block under the abdomen: 2. Divide by a vertical incision the trapezius, splenius, rhomboideus, latissimus dorsi, and serrati postici; reflect the divided portions inwards and outwards. A young subject, from ten to twelve years of age, is best adapted for the study of these muscles, from the facility with which the different fasciculi may be separated. For the same reason, one that is much infiltrated with serum is preferable to one in which the parts are dry.

The lumbo-sacral portion is usually called the *common mass of the sacro-lumbalis and longissimus dorsi.* It forms the fleshy part of the loins, and is called the *fillet* in the lower animals: it is the most highly developed in man, in whom it exerts a constant and powerful action during the erect posture: it appears to be the common origin of the posterior spinal muscles, whence the name of *common mass:* it fills up entirely the lumbo-sacral groove, and even projects backwards and laterally in robust subjects.

It is of small size in the sacral region, is much enlarged at the middle of the lumbar region, at the upper part of which it again diminishes, so as to resemble two cones united by their bases.

Attachments. The common mass *arises* from the whole extent of the sacro-iliac groove, and from the anterior surface and external border of an extremely strong aponeurosis, formed of parallel vertical fibres, and strengthened by a superficial layer directed obliquely. This *aponeurosis of origin for the posterior spinal muscles* (*d*, *fig.* 107.) is inserted *on the inside* to the sacral ridge, to the summits of the spinous processes of the lumbar and three lower dorsal vertebræ, and to the corresponding supra-spinous ligaments: *on the outside*, to the series of eminences representing the transverse processes of the sacral vertebræ, and to the back part of the crest of the ilium: it gives attachment to many of the fibres of the glutæus maximus. It is short on the outside, and very long on the inside, reaching in the latter direction to the middle of the dorsal region under the form of parallel and regular bands (*d*, *fig.* 107.).

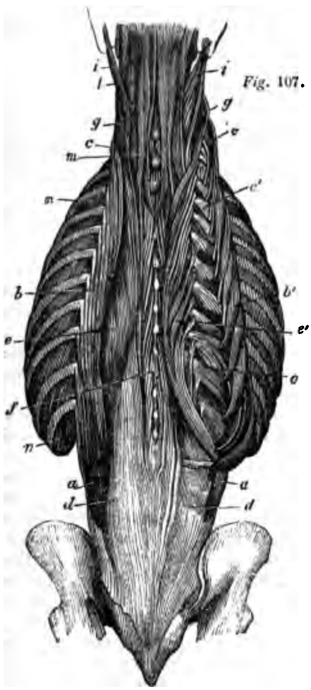
Arising from these different origins the common mass appears at first extremely simple in its composition, consisting of fibres passing vertically up-

wards. But if the aponeurosis be detached from its spinal insertions, and turned outwards, it will be seen that the common mass is essentially composed of two portions — one internal and anterior, the *lumbo-sacral portion of the transverso-spinalis*; and the other external and posterior, the *lumbo-sacral portion of the sacro-lumbalis and longissimus dorsi.*

1. The *lumbo-sacral portion of the transverso-spinalis* * occupies all the sacral groove, and that part of the lumbar groove situated within the articular processes. It is perfectly distinct in the loins, being separated from the common mass by loose cellular tissue traversed by vessels and nerves. It *arises* from the *articular processes* of the lumbar vertebræ by flat tendons, directed obliquely inwards and upwards, and terminating upon the posterior surface of the muscle: by the union of their contiguous edges an aponeurosis is formed, which is itself blended along one of its borders with the deep surface of the common aponeurosis of origin. From these tendons the fleshy fibres arise, and having united into bundles, terminate by other tendons at the spinous processes of the vertebræ above. In the sacral region this portion of the transverso-spinalis is less distinct, but it may be easily seen that it occupies the whole of the sacral groove, and that the corresponding portion of the aponeurosis of origin affords attachments to it alone.

2. The external and posterior portion of the common mass, or *lumbo-sacral portion of the sacro-lumbalis and longissimus dorsi*, is entirely without the sacral groove, but occupies that part of the lumbar groove situated on the outer side of the articular processes.

Fig. 107.



It *arises*, 1. from all the lumbar portion of the common aponeurosis; 2. from an extremely strong tendon, which is attached to the posterior superior spinous process of the ilium; 3. from the posterior fourth of the crest of the ilium, internally by tendinous, and externally by muscular fibres. The thick fleshy mass proceeding from these different origins is disposed of in the following manner: — the greater part of the fibres pass directly upwards to the dorsal region, forming the proper commencement of the sacro-lumbalis (*a a*, *fig.* 107.). The remaining fibres are directed forwards, and are arranged into two sets of bundles, one of which is inserted into the summits of the transverse processes, forming the *external* or *transverse* fasciculi; and the other into the tubercles of the articular processes, forming the *internal* or *articular* fasciculi. These two sets of fibres constitute the proper origin of the *longissimus dorsi* (*d d*, *fig.* 107.).

Relations. The common mass is covered behind by the united aponeuroses of the latissimus dorsi and serratus posticus inferior, and by the posterior layer of the aponeurosis of the transversalis; in front, it corresponds to the lumbar groove, the inter-transversales muscles of the loins, and the middle layer of the aponeurosis of the transversalis, which separates it from the quadratus lumborum; on the inside,

* [This corresponds to the inferior or lumbo-sacral fasciculi of the multifidus spinæ.]

it corresponds to the spinous processes; and on the outside, to the angle of union between the posterior and middle layers of the aponeurosis of the transversalis. In this way it is completely inclosed in an osteo-fibrous sheath.

Thoracic Portion of the Posterior Spinal Muscles.

The transverso-spinalis muscle may be completely isolated from the others in this region. We have seen the distinction between the sacro-lumbalis and longissimus dorsi commenced at the upper part of the lumbar region; in the back they are completely separated by some loose cellular tissue and the posterior branches of the dorsal nerves and vessels.

The *thoracic portion of the sacro-lumbalis* (*b b'*, *fig.* 107.) consists of a continuation of the vertical or external fibres of the common mass; as it proceeds upwards it becomes more and more slender, and is divided into a series of fasciculi, which are inserted successively into the angles of the ribs, by means of tendinous prolongations, that extend for a considerable distance upon the posterior surface of the muscle. It was the existence of these aponeurotic processes, the contiguous edges of which are often united, that induced Winslow to compare the muscle to a palm leaf. In this manner the muscular fasciculi are soon expended, terminating at about the sixth rib, but the muscle itself is continued into the neck by means of *accessory fibres*, which may be exposed by turning the muscle outwards, after separating it from the longissimus dorsi (as at *b'*): twelve long thin tendons will then be seen to arise from the upper portion of the angles of the twelve ribs, and to pass outwards and upwards: to these succeed fleshy fasciculi, which terminate in aponeurotic processes, situated on their posterior surfaces, and having precisely the opposite direction. These accessory bundles (*c c'*, *fig.* 107.; *i*, *fig.* 108.) have been very well described by Diemerbroëk under the name of *cervicales descendens*, and by Steno under that of *musculus accessorius ad sacro-lumbalem*; the four or five superior bundles form the *transversaire grêle* of Winslow, and the *cervicalis descendens* of Albinus.

The *thoracic portion of the longissimus dorsi* (*e e'*, *fig.* 107.) is larger than the preceding muscle, to the inner side of which it is situated: it diminishes much less rapidly, because the common aponeurosis (*d*) is extended in the form of bands upon its posterior aspect, which afford attachment to additional fleshy fibres. This muscle is a continuation of the internal or articular, and the external or transverse fasciculi, described as existing in the lumbar region, and is itself divided into three orders of fasciculi, one *external* and two *internal*. 1. The *external* or *costal* fasciculi form the continuation of the transverse bundles of the lumbar portion of the muscle, and are inserted by very thin tendons into the space between the angles of the ribs and the summits of the dorsal transverse processes (*e'*, *fig.* 107.). 2. The *first set of internal or the spinous fasciculi* are inserted into the spinous processes of the five or six superior dorsal vertebræ; and as they arise from tendinous bands attached to the summits of the spinous processes of the lower dorsal vertebræ, and of that of the first lumbar vertebra, Winslow considered them as forming a separate muscle, which he called *le long épineux du dos* (spinalis dorsi, *f*, *fig.* 107.). 3. The *second set of internal*, or *the transverse fasciculi*, are a continuation of the articular fasciculi of the lumbar region; they constitute the principal termination of the longissimus dorsi, and are attached by very long and thin tendons to the transverse processes of the dorsal vertebræ.

The *thoracic portion of the transverso-spinalis* * (partly seen in *fig.* 108.) is reduced to a very narrow band, concealed by the longissimus dorsi: it *arises* by very long and delicate tendons from the lower dorsal transverse processes, and is *inserted* by others equally similar, long and slender, into the summits of

* [This corresponds to the semispinalis dorsi, and to the dorsal portion of the multifidus spinæ of Albinus.]

the superior dorsal spinous processes, some pale fleshy fibres connecting the two series of tendons.

Connections. The dorsal portion of the posterior spinal muscles entirely fills the dorsal groove, limited on the outer side by the angles of the ribs. They are covered by several muscular layers, the nearest of which is formed by the two serrati postici and their connecting aponeurosis, which completes the sheath enclosing the long muscles of the back: they are, moreover, separated from the skin by the rhomboid, trapezius, and latissimus dorsi.

The Cervical Portion of the Posterior Spinal Muscles, the Transversalis Colli, and the Trachelo-mastoideus.

Cervical portion of the sacro-lumbalis, or *cervicalis descendens.* The sacro-lumbalis, whose original fibres are found to terminate at and upon the sixth rib, is continued by means of its accessory fasciculi (*c c'*, *fig.* 107.) up to the transverse processes of the four or five inferior cervical vertebræ (*i*, *fig.* 108.), into the summits of which it is inserted by very slender tendons. The number of these terminating fasciculi varies in a remarkable manner. Indeed, the splenius, the transversalis colli, the sacro-lumbalis, and even the levator anguli scapulæ, are so closely connected, that upon examining their cervical insertions only, these might all be ascribed to a single muscle. The cervical portion of the sacro-lumbalis is covered by the levator anguli scapulæ, and can only be exposed by turning this muscle outwards.

The *cervical portion of the longissimus dorsi*, or the *transversalis colli*, and the *trachelo-mastoid.* The extent of the longissimus dorsi is limited to the back; its highest internal or spinous fasciculus seldom reaches the spinous process of the first dorsal vertebra: its highest external or costal fasciculus is attached to the second, sometimes even to the fourth rib, and its highest transverse fasciculus is inserted into the transverse process of the first dorsal vertebra. In some very rare cases a few internal fasciculi reach the cervical vertebræ: I have seen one of them terminate by becoming attached both to the transverse process of the third cervical vertebra and to the complexus. The longissimus dorsi is, however, prolonged by accessory fasciculi as far as the third cervical vertebra. These fasciculi can only be identified by their direction (for they can never be completely separated from this muscle): they form a distinct muscle known as the *transversalis colli* (transversalis cervicis, *Albinus*, *g g*, *fig.* 107.).

By reflecting outwards the upper part of the longissimus dorsi, they may be exposed, varying in number, and arising from the summits of the transverse processes of the third, fourth, fifth, sixth, and sometimes seventh and eighth dorsal vertebræ by long thin tendons, and inserted by other tendons into the posterior tubercles of the transverse processes of the five inferior cervical vertebræ (*l*, *fig.* 108.): the transversalis colli is covered by the longissimus dorsi, the splenius, and levator anguli scapulæ, and rests upon the trachelo-mastoid and complexus.

The *trachelo-mastoideus* (complexus minor, *i i*, *fig.* 107.) may be regarded as another accessory muscle to the longissimus dorsi, which it continues up to the head. In order to expose its origin the transversalis colli must be reflected outwards (as in *fig.* 107.). It *arises* from the angles between the transverse and articular processes of the four inferior cervical vertebræ, by four small tendons; or sometimes by a continuous aponeurotic plane. From thence the fibres proceed upwards, and form a small muscle which is inserted into the mastoid process, in a small furrow to the inside of the digastric groove. This small muscle is almost always interrupted by a tendinous intersection near its mastoid insertion.

The *cervical portion of the transverso-spinalis.** While the preceding

* If we were to follow the order of super-imposition rigorously, the complexus should be described before this muscle, which cannot be brought into view until the former is removed.

muscles present only a few fasciculi in the neck, the transverso-spinalis* undergoes an enlargement in this region, so as to occupy the entire cervical groove (*a* and *b*, *fig.* 108.). In carnivora, this portion of the muscle is enormously developed (much more so than in man), in consequence of those animals using the head and neck in seizing or struggling with prey. In mammalia, as in man, the dorsal portion of the transverso-spinalis is, as it were, but a rudiment in the lumbo-sacral region; the muscle is larger in man than in other animals, on account of his erect posture. Albinus described the enlarged cervical portion as a separate muscle, viz. the *spinalis cervicis*.

In the neck, as in the other regions, the transverso-spinalis is a collection of super-imposed fasciculi, which *arise* from the transverse processes of the five or six upper dorsal, and from the articular processes of the five lower cervical vertebræ, and are *inserted* into the spinous processes of the six lower cervical vertebræ: the highest and the largest fasciculus is attached to the axis. This muscle, which would have been much better named *articulo-spinalis*, is composed of several layers of fasciculi, placed one above the other, and extending from the whole length of the articular processes and laminæ of the vertebræ below, to the whole length of the spinous processes and laminæ of the vertebræ above. The length of these layers diminishes progressively from the more superficial (*a*, *fig.* 108.) to the deep-seated ones (*b*); the latter extend only from one vertebral lamina to another, and might be considered as proper muscles of the laminæ, and not as a part of the transverso-spinalis muscle. The most superficial layer is composed of radiating fasciculi, diverging from one articular process to the summits of several of the spinous processes.

The Complexus.

Dissection. Divide the splenius perpendicularly to the direction of its fibres, and reflect the two parts upwards and downwards; turn outwards the upper portions of the longissimus dorsi, the transversalis colli, and the trachelo-mastoid (see *fig.* 107.).

The *complexus* (*l*, *fig.* 107.) is situated beneath the splenius at the posterior part of the neck and upper part of the back. It is a flat muscle, broad above, but terminating in a point below.

Attachments. It *arises*, 1. from the transverse processes of the five or six superior dorsal vertebræ; 2. from the articular tubercles and the angular depression formed between them and the transverse processes of the four inferior cervical vertebræ; 3. sometimes from the spinous processes of the seventh cervical and two upper dorsal vertebræ: it is *inserted* upon the side of the external occipital crest into the inner half of the rough space comprised between the two semi-circular lines. The origins of this muscle consist of tendons from which the inferior fleshy fibres pass vertically upwards, the superior ones obliquely inwards and upwards, becoming gradually shorter and more nearly horizontal. The muscular fibres are interrupted by some very remarkable tendinous intersections. Thus on the inside, the fleshy fasciculus arising from the sixth, fifth, and fourth dorsal vertebræ, gives origin to a tendon which proceeds along the inner edge of the muscle, and at the distance of an inch and a half, or two inches, becomes the origin of another fleshy fasciculus which is attached to the side of the occipital crest; hence the name of *biventer cervicis*, given by Eustachius to the whole complexus, and by Albinus to this inner portion only (*m*, *fig.* 107.). More externally, there is another flat tendon extending along the posterior surface of the muscle, from the outer edge of which an aponeurotic intersection passes in a zig-zag course obliquely outwards and

* [This portion of the transverso-spinalis corresponds to the semi-spinalis colli (*a*, *fig.* 108.), and the cervical fasciculi (*b*) of the multifidus spinæ of Albinus.]

upwards. It is not uncommon to find another small digastric fasciculus with a separate tendon, on the anterior surface of the muscle.

Relations. The complexus is covered by the trapezius, splenius, longissimus dorsi, transversalis colli, and trachelo-mastoid, and covers the transverso-spinalis and the recti and obliqui capitis. Its inner edge is separated from the muscle of the opposite side by a considerable quantity of adipose tissue, and by a prolongation of the ligamentum nuchæ.

The Interspinales Colli.

The interspinales muscles are distinct in the neck only. It is generally admitted that there are five pairs, the first of which extends between the axis and the third cervical vertebra, and the last between the seventh cervical and first dorsal vertebræ. They are small quadrilateral muscles extending from one of the borders of the groove in the spinous process below, to the corresponding lip of the next process above. Externally they are in relation with the transverso-spinalis, and are separated from each other internally by cellular tissue and an aponeurotic lamina.

The Recti Capitis Postici, Major and Minor.

The *rectus capitis posticus major* (*e*, *fig.* 108.) may be regarded as an *axoido-occipital*, and the *rectus minor* (*d*) as an *atloido-occipital inter-spinalis* muscle.

Fig. 108.

They both *arise* tendinous, the smaller from the tubercle on the posterior arch of the atlas, and the greater from the superior tubercle of the spinous process of the axis (2); and increasing in size, they both pass obliquely upwards and outwards. The rectus major, which is much the larger and more oblique, is *inserted* to the outer side of the inequalities situated below the inferior semi-circular line of the occipital bone; the rectus minoris *inserted* to their inner side. The name of *recti* is not therefore very appropriate, for both of them (but more especially the larger one) are directed obliquely; but they are so called in contra-distinction to two neighbouring muscles which are much more oblique. The obliquity of these muscles (by increasing their length) allows of more extended movements, and at the same time enables them to assist in rotating the head.

The Obliquus Capitis Major or Inferior, and Obliquus Minor or Superior.

The *obliquus major* or *inferior* (*f*, *fig.* 108.), as far as its insertions are concerned, may be called the axoido-atloid spino-transversalis; it resembles in fact a thick fasciculus of the longissimus dorsi. The *obliquus minor* or *superior* (*g*) may for the same reason be called the atloido-occipital transverso-spinalis, resembling a thick fasciculus of that muscle. The *obliquus major* arises from the apex of the spinous process of the axis, on the outer side of the rectus major (*e*), and above the transverso-spinalis (*i.e.* the semispinalis colli and multifidus spinæ conjoined, *a* and *b*); it forms a thick cylindrical bundle, passes almost horizontally outwards, and is *inserted* behind and below the transverse process of the atlas, which is excavated for this purpose. It is the axoido-atloideus of Chaussier. The *obliquus minor* (atloido-sub-mastoideus) *arises* by some very long tendinous fibres from the upper part of the transverse process of the atlas, proceeds at an angle of about 45° towards the occipital bone, into

which it is *inserted* not far from the mastoid process, by some tendinous fibres, less distinctly marked than those of its origin.

From this difference of direction, it follows that the rectus major and the two obliqui form on each side an equilateral triangle; in the interval between the two triangles a considerable part of the recti minores is seen.

Relations. The recti and obliqui capitis are covered behind by the complexus, from which they are separated by a very strong aponeurotic lamina and much cellular tissue; they cover the posterior arch of the atlas, with the posterior ligaments of the atloido-occipital and atloido-axoid articulations.

General View of the Posterior Spinal Muscles.

After the preceding description it will now be easy to comprehend the general guiding principles in the arrangement of the innumerable, and at first sight inextricable fasciculi which constitute the fleshy mass known by the general name of the posterior spinal muscles. We shall first recall to mind, that the levers to which all these muscles are ultimately attached, are, 1. The row of spinous processes; 2. The row of articular processes; and 3. The row formed by the transverse processes and the ribs, which for many reasons may be regarded as extensions of those processes.

We shall suppose these three series of levers, and therefore the several points of insertion, to be represented by three vertical lines.

We must remember also that the dorsal transverse processes are upon the same line as the lumbar and cervical articular processes, and that the ribs are upon the same line as the lumbar transverse processes and the anterior roots of the cervical transverse processes. (See OSTEOLOGY, p. 31.) These data being admitted we can now reduce all the posterior spinal muscles into the four following orders of fasciculi, two being vertical, and two oblique.

1. The *internal vertical* or *spinous* muscles, comprising the spinalis dorsi (*i. e.* the internal and superficial portion of the longissimus dorsi), the interspinalis of the neck, and the recti postici of the head. 2. The *external vertical lateral*, or *transverse* muscles, connected with the transverse or costiform processes. They comprise the sacro-lumbalis and the inter-transversales, among which the quadratus lumborum may be included. 3 The *spino-transverse* and *spino-articular* * *oblique* muscles, including the longissimus dorsi, with its accessories the transversalis colli and trachelo-mastoid, the splenius and the obliquus major. 4. The *transverso-spinous* and *articulo-spinous* * *oblique* muscles; viz. the transverso-spinalis, the complexus, and the obliquus capitis minor.

Action of the Posterior Spinal Muscles.

Having once established the general principles according to which the posterior spinal muscles are arranged, it is very easy to determine the mode of action of each, and to reduce to very simple elements a mechanism, to all appearance so complicated.

1. The long and short spinous fasciculi being vertical, directly extend the vertebral column; such is the action of the spinalis dorsi and interspinalis colli; the recti capitis, at the same time that they extend the head, rotate it also to the side on which the muscles are acting. When the recti muscles of both sides act simultaneously the head is drawn directly backwards.

2. The fasciculi of the sacro-lumbalis being vertical and lateral, erect the vertebral column, and incline it to one side, when only one set of muscles acts; when both sets act together, they extend it directly backwards.

3. As the fasciculi of the longissimus dorsi, belonging to the spino-transverse

* [The terms spino-transverse and spino-articular are applied to fasciculi passing *upwards from* the spinous *to* the transverse and articular processes; transverso-spinous and articulo-spinous to such as proceed *upwards from* the transverse and articular *to* the spinous processes.]

and spino-articular group, have their fulcra upon the spine, and are inserted into the articular and the transverse processes or ribs, they conspire in erecting the vertebral column, and keeping it in that position. But from their obliquity they produce a slight movement of rotation, those fibres which are attached to the articular processes having less effect than those connected with the transverse processes. In this movement the front of the body is turned to the side on which the muscles are situated. When the muscles of both sides act together the spine is extended directly backwards. The splenius, which is the representative of the longissimus dorsi for the neck and head, acts in the same way, but with greater effect. Thus by the contraction of the left splenius, the face is turned to the left side, and the head is drawn backwards and to the right side. The obliquus inferior also acts in the same direction. When the two splenii and the two inferior oblique act together, the head is inclined directly backwards.

4. The fixed insertions of the transverso-spinalis being at the articular or transverse processes, and their moveable points at the spinous processes, besides the common effect of erecting the vertebral column they are also able to rotate it, so that the anterior region of the trunk is turned to the opposite side. From its obliquity this muscle is the principal rotator of the vertebral column. The complexus, which is its representative in the neck, acts upon the head in the same manner, but in a more remarkable degree. Thus, by the contraction of the complexus of the left side, the face is turned to the right side, and the head is inclined backwards upon the left side, so that in rotation it acts in a precisely opposite direction to the splenius. When all these muscles act together the trunk is simply drawn erect. The superior oblique assists the complexus in the movements of the head.

Lastly, we may now understand the successive actions which take place along the whole extent of the posterior spinal muscles. The sacrum and the iliac bones furnish a fulcrum for the fasciculi which move the lumbar region: this latter being fixed, then becomes the fulcrum for those that move the dorsal region, and so on to the head, which alone has independent muscles. It is impossible to extend backwards the dorsal region, and the lower part of the cervical, without at the same time erecting the lumbar region; but the head may be moved at will, independently of the vertebral column.

The posterior spinal muscles maintain in equilibrium the weight of the whole trunk; hence the lassitude experienced in the back, but especially in the loins, by long-continued standing, walking, or even sitting without a support to the back; and hence the relief afforded by the recumbent posture.

Rotation we have seen scarcely exists in the loins, the back, or the lower part of the neck; but at the upper part of the neck it is very extensive, and here the rotator muscles are proportionally strong, and directed very obliquely.

MUSCLES OF THE ANTERIOR ABDOMINAL REGION.

The obliquus externus abdominis. — Obliquus internus and cremaster. — Transversalis abdominis. — Rectus abdominis. — Pyramidalis.

THE muscles of the anterior abdominal region are, the *external oblique*, the *internal oblique*, the *transversalis*, the *rectus*, and occasionally the *pyramidalis*; being ten in the whole, five on each side.

The Obliquus Externus Abdominis.

Dissection. 1. Make an incision through the skin of the abdomen extending from the cartilage of the eighth rib obliquely downwards and inwards, dividing at the same time the very firm layer of cellular tissue, which immediately covers the muscle. 2. During the preparation of this, as well as all the other abdominal muscles, place a block under the loins, and in the dissection follow exactly the direction of the muscular fibres.

The *great* or *external oblique* muscle of the abdomen (*o*, *fig.* 106. and *a*, *fig.* 109.), so called from the direction of its fibres (obliquus descendens, forms the most superficial muscular layer of the abdominal parietes, on the sides and front of which it is situated: it is very broad, quadrilateral, and curved upon itself.

Attachments. It *arises* from the external surfaces and lower borders of the seven or eight inferior ribs, and is *inserted* into the anterior half of the external lip of the crest of the ilium, into the external edge of the anterior abdominal aponeurosis, and by it into the linea alba. The upper or costal attachments consist of seven or eight angular tongues, or *digitations*, fleshy and tendinous in their structure, and arranged in an oblique line, running downwards and backwards.

These digitations increase in size from above downwards as far as the eighth rib, and then diminish to the twelfth. The four or five superior digitations are interposed, like the fingers of the two hands (whence the name), between similar prolongations of the serratus magnus. The three or four lower digitations between hose of the latissimus dorsi, by which they are covered. This series of ostal attachments constituting the upper edge of the muscle, represents a errated curved line, the convexity of which is directed upwards and back'ards.

The first digitation is attached close to the cartilage of the corresponding b, the succeeding ones are further and further removed from the first, and le last is inserted into the apex of the cartilage of the last rib.

From these attachments the fleshy fibres proceed in different directions: the sterior pass nearly vertically downwards; the middle obliquely downwards id inwards, and the upper almost horizontally inwards; the posterior termite by short tendinous fibres at the crest of the ilium; the anterior at the ternal concave edge of a broad aponeurosis, which forms the superficial rer of the anterior abdominal aponeurosis, and by interlacing with the corsponding structure of the opposite side, concurs in forming the linea alba, d is folded upon itself below, to form the crural arch, or Poupart's ligament. e APONEUROLOGY.)

It should be remarked, that the fibres of the external oblique follow exactly the same direction as those of the external intercostal muscles.

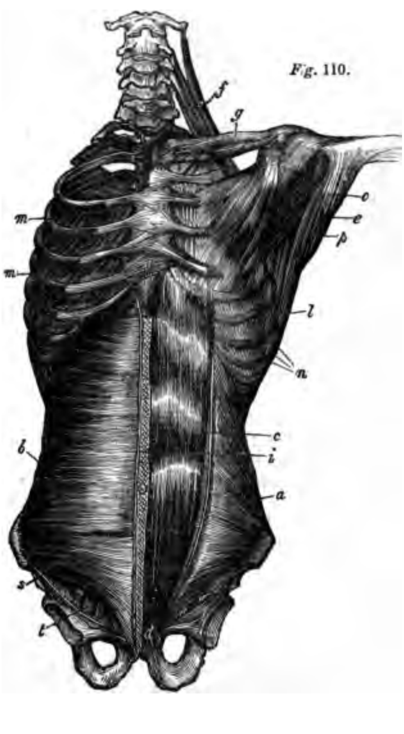
Relations. The external oblique is covered by the skin, a considerable quantity of adipose tissue, and behind by a small portion of the latissimus dorsi. It covers the internal oblique, the anterior extremities and the cartilages of the seven or eight inferior ribs, together with the corresponding external intercostal muscles. The most remarkable relation is that of its posterior border with the outer edge of the latissimus dorsi. Most commonly this border is covered by the latissimus dorsi; but sometimes a triangular space exists between them, which has been much noticed since Petit described a hernial protrusion in it, which he called lumbar hernia.

Action. The external oblique performs a threefold action:—1. It compresses the abdominal viscera during any exertion, or in expulsion of the fæces, in labour, &c: 2. it depresses the ribs, and thus indirectly flexes the vertebral column: 3. from its obliquity, it rotates the vertebral column, through the medium of the ribs, so that the fore part of the trunk is turned to the opposite side. When the two muscles act together, the thorax is inclined directly forwards. Hitherto we have supposed that the moveable point of the muscle is at the ribs: if, on the contrary, the thorax be fixed, it then draws the pelvis upwards, and rotates the vertebral column, so that the fore part of the pelvis is turned to the same side as the contracting muscle.

The Obliquus Internus, and the Cremaster.

Dissection. Divide the external oblique across the direction of its fibres, *i. e.* downwards and backwards.

The *small* or *internal oblique of the abdomen* (obliquus ascendens, *p*, *fig.* 106. and *a*, *fig.* 110.) is a broad irregularly quadrilateral muscle, much broader in front than behind, and smaller and thinner than the preceding. It occupies the anterior, lateral, and posterior parts of the abdomen.



Attachments. It *arises* from the spinous processes of the lumbar vertebræ, from the anterior three fourths of the interval between the borders of the iliac crest, and from the crural arch (Poupart's ligaments). It is *inserted* into the lower edges of the cartilages of the ninth, tenth, eleventh, and twelfth ribs, and into the linea alba by means of the middle layer of the anterior abdominal aponeurosis. The spinal fibres take their origin through the medium of the posterior abdominal aponeurosis: they are few in number. The iliac portion of them arise by very short tendinous fibres, and those which proceed from the crural arch arise from the sort of groove situated on its upper surface. From this threefold origin the fibres proceed in different directions; the posterior almost vertically up-

wards; those which arise from the crest of the ilium obliquely upwards and inwards, becoming longer and more oblique anteriorly; those which proceed from near the anterior superior spinous process of the ilium are horizontal; and lastly those which arise from the crural arch pass obliquely downwards and inwards. The posterior fibres terminate at the lower edge of the cartilages of the four inferior ribs, and are continuous with the internal intercostal muscles, in the intervals between the tenth and eleventh and eleventh and twelfth ribs, indicating the analogy between these muscles. I have often observed the insertion into the last rib to be wanting. The middle fibres, which are the most numerous, terminate at the external edge of the middle layer of the anterior abdominal aponeurosis. The fibres arising from the crural arch are few in number, pale, and fasciculated; some terminate at the pubes, passing behind the inguinal or external abdominal ring; others proceeding from the ring, in the male, form the cremaster muscle.

Relations. It is covered by the external oblique and behind by a small portion of the latissimus dorsi; and it lies superficially to the transversalis. The most important relations are those of its inferior edge, with the inguinal ring of the external oblique, which it partly closes on the inner side, as Scarpa and Bichat have well pointed out, and with the spermatic cord, which passes beneath it, and during the descent of the testicle draws with it some of the lower fibres of the muscles; and hence the looped arrangement they assume.

The *cremaster.* The loops so well described by M. Jules Cloquet are very variable, and do not always appear to me to constitute the entire muscle. According to this anatomist, the cremaster is nothing more than the lower fibres of the internal oblique, that had been intangled with the testicle during its descent, forming loops in front of the cord, the concavity of which is directed upwards, and which may be traced to the bottom of the scrotum. But I have often been convinced, from the examination of subjects in which the cremaster was much developed, that this muscle (*b, figs.* 109. 137.) consists principally of a longitudinal fasciculus, partly derived, it is true, from the lower fibres of the internal oblique, but consisting partly also of proper fibres arising from the crural arch, near the external pillar of the ring; and that this fasciculus is lost upon the proper sheath of the cord, to which it is intimately united. The office of this muscle is to raise the entire testicle. The slow vermicular motion observed in the scrotum during the venereal orgasm, or from the action of cold, is not at all connected with it.

The *actions of the internal oblique* are, 1. Compression of the abdominal viscera; 2. Depression of the ribs, and consequently flexion of the trunk; 3. Rotation of the trunk, so that the fore part of the body is turned to the same side. The right internal oblique, therefore, co-operates with the left external oblique; when it acts with its fellow, the thorax is drawn directly towards the pelvis; but if the chest is fixed, they move the pelvis upon the loins.

The Transversalis Abdominis.

Dissection. Make a horizontal section of the internal oblique; 2. Dissect with care the two flaps of this muscle, following the direction of the fibres of the transversalis; 3. In order to obtain a good view of the costal attachments, open the abdomen and examine them on the inner surface of the ribs this may be omitted until the diaphragm is to be inspected.

The *transversalis abdominis*, so named from the direction of its fibres, is situated more deeply than the two preceding muscles, and like them is irregularly quadrilateral (*b, fig.* 110.).

Attachments. It *arises* from the six lower ribs, from the anterior three-fourths of the internal lip of the crest of the ilium, and from the spinous and transverse processes of the lumbar vertebræ. It is *inserted* into the linea alba by means of the deep layer of the anterior abdominal aponeurosis. The costal attachments consist of fleshy digitations interposed between those of the dia-

phragm, the two muscles being actually continuous at the two inferior intercostal spaces; the vertebral attachments are effected by means of the posterior abdominal aponeurosis; and from the ilium it arises by very short tendinous fibres internally to the small oblique. From these three origins the fleshy fibres proceed parallel to each other and horizontally inwards; the lower ones alone are slightly inclined downwards and inwards; the middle fibres are the longest. They are all inserted into the external convex edge of a tendinous expansion, which constitutes the posterior layer of the anterior abdominal aponeurosis.

Relations. The transversalis is covered by the internal oblique, and rests upon the peritoneum, from which it is separated by a fibrous lamina, which is very distinct in front, where it is named the *fascia transversalis.*

Actions. 1. It acts more powerfully upon the abdominal viscera than any of the preceding muscles, compressing them strongly like a girth, against the vertebral column, and assisting greatly in the process of defæcation. 2. It draws inwards the ribs to which it is attached, and thus materially assists in expiration.

The Rectus Abdominis.

Dissection. 1. The subject being laid upon its back, place a block under the loins; 2. After having removed the skin, make a vertical incision through the strong aponeurosis at about two fingers breadth from the linea alba; 3. Dissect off the two flaps inwards and outwards. The adhesions between this aponeurosis and the muscle are, however, so intimate at many points, that it is impossible to separate them.

The *rectus abdominis* (*c, fig.* 110.) is *situated* at the anterior and middle part of the abdomen on each side of the linea alba, and occupies the space between the pubes and the cartilage of the fifth rib. It is flattened like a riband in front and behind; it is about three or four fingers' breadth wide above, and only two below. Its breadth is generally in an inverse proportion to its thickness.

Attachments. It *arises* from the upper edge of the os pubis, in the space between the spine and the symphysis; and is *inserted* in front of and below the cartilage of the seventh rib and costo-xiphoid ligament, to the cartilages of the fifth and sixth ribs, and sometimes to the bone also.

The pubic attachment is a flat tendon, consisting of two very distinct portions, of which the external is the larger. This tendon is continuous by its external border with the fascia transversalis. It is separated from its fellow of the opposite side by a very narrow and thick fibrous septum, which forms the lower part of the linea alba. Sometimes the internal tendinous fibres intersect with those of the opposite side in front of the symphysis pubes; and some fleshy fibres often arise from the sides of the linea alba. The presence or absence of the pyramidalis affects the size of the lower part of this muscle. From this tendinous origin the fleshy fibres proceed vertically upwards (whence the name of *rectus*). At the upper part, where they are prolonged in an expanded form upon the thorax, they are slightly oblique from within outwards, and divided into three unequal portions: the internal, the smallest, is attached to the cartilage of the seventh rib and to the costo-xiphoid ligament; the middle, which is larger, is fixed to the cartilage of the sixth rib; and the external, by far the largest, to the cartilage of the fifth rib. Very often a small portion of the muscle is inserted into the base and edges of the xiphoid cartilage, thus justifying the name of *sterno-pubien* given to it by Chaussier. It is not uncommon to find this muscle give off a fourth bundle to the fourth rib, and even an aponeurotic expansion to the sterno-cleido-mastoid. The rectus is interrupted by two, three, four, or five *tendinous intersections*, which pass transversely or obliquely across the muscle in a flexuous or zig-zag course, seldom occupying either the entire thickness or width of the muscle, which they divide into so many smaller muscles. There are always more intersections above than below the umbilicus.

ms. This muscle is contained in a very strong tendinous sheath, formed by the anterior abdominal aponeurosis, is thicker in front hind, much stronger below than above, and completely isolates the Below and behind, this sheath is deficient, in which situation the passing through the openings, *fig.* 110., in the aponeurosis of the trans- rests directly upon the peritoneum; the upper and posterior part of th is also wanting, so that the muscle is in immediate contact with the s of the fifth, sixth, seventh, eighth, and ninth ribs, and with the cor- ng intercostal muscles. The linea alba occupies the interval between muscles, which is much larger above than below the umbilicus; but important of all the relations of the rectus is that of its posterior sur- the epigastric artery, which we shall hereafter notice.

s. This muscle, having its fixed point below, and its moveable at- ts divided between the fifth, sixth, and seventh ribs, depresses the orax, and consequently the vertebral column. Few muscles are so ly situated as the rectus, which both acts upon a very long lever, and d at right angles to the part to be moved.

e rectus forms a curve, the convexity of which is directed forwards, not contract without becoming rectilinear, it follows that the first its contraction is the compression of the abdominal viscera; hence it expelling the contents of the bladder, rectum, and uterus; it aids in n, by depressing the ribs and by keeping them fixed, when the tho- ilated, it assists in the performance of any effort. When the fixed above, the rectus becomes a flexor of the pelvis.

are the uses of the intersections? It is generally stated that their to increase the number of fibres, and thereby augment the force of cle; and in support of this a principle is adduced, which is incontes- itself, viz. that the power of a muscle is in a direct ratio to the number res; for if each fibre represent one partial power, the more of these ter must be the total power. But it has been overlooked, that this applies to fibres arranged side by side, not to those which are placed nd. In fact, it may be experimentally shown, that when two equal e applied to a lever, parallel to each other, they produce double the her would have done separately; but if one be made continuous with r, and both are then applied to the same lever, they only produce an ual to that of either *per se.* These intersections, therefore, do not in- e power of the muscle; nor do they diminish the extent of motion, sum of the contractions of the small muscles into which they divide , is equal to that of an undivided muscle. What then are the uses of tersections? Can it be intended, as Bertin has said, to associate the muscles with the recti, by means of the intimate adhesions existing them and the aponeuroses? *

The Pyramidalis.

yramidalis (*d*, *fig.* 110.), a small triangular muscle which is often de- ccupies the lower part of the abdomen on each side of the linea alba. from the pubis and the anterior ligament of the symphysis by ten- ibres, from which the fleshy portion proceeds upwards, the internal rtically, the external obliquely upwards and inwards, and terminates nted extremity which is attached to the linea alba, and forms the apex uscle, the base being at the os pubis. It is covered by the aponeuroses

* considers these adhesions as true points of attachment for the muscles of the ab- that when the rectus contracts, it acts not only upon the pubes, but also upon the he ilia, through the medium of the abdominal aponeuroses. Professor Bérard, who ward this forgotten opinion of Bertin (*Répert. Génér. des Sc. Méd.* art. ABDOMEN), bserves, that the obliquus internus only adheres to the rectus. In the same article declares, he is not satisfied that the intersections increase the power of the recti

the obliqui and transversalis muscles, and rests upon the rectus. The lower
rt of the rectus and the pyramidalis are united together. When the latter
wanting, the lower end of the rectus is proportionally increased in size, and
ce versâ. There are sometimes two pyramidales on one side, and one on
ıe other; sometimes the two are of unequal size. In a negro I found them
xtending beyond the middle of the space between the pubis and the umbilicus.

Action. It is a tensor of the linea alba.

DIAPHRAGMATIC REGION.

The Diaphragm.

Dissection. — Description. — Attachments. — Relations. — Action.

Dissection. In order to expose this muscle, it is necessary to open the abdomen and remove all the abdominal viscera, taking great care in detaching the liver, stomach, and kidneys. Tie the œsophagus and vena cava where they pass through the diaphragm, and cut them below the ligature. Raise the peritoneum with the fingers or forceps, and tear it gently away; thus exposing the lower surface of the muscle without using the scalpel. All the insertions of the diaphragm are well seen on this surface. In order to study the convex surface of the muscle, another subject should be provided, and the thorax opened before the abdomen. This is the only method by which a good idea of it can be obtained; for when the abdomen has been previously opened, the muscle becomes relaxed as soon as the thorax is cut into, and affords no idea of its naturally vaulted form.

The *diaphragm* (septum transversum, *a a*, *fig.* 111.), which exists in mammalia only, is, according to the expression of Haller, with the exception of the heart, the most important muscle of the body. It is a muscular septum, *situated* obliquely at the junction of the upper with the two lower thirds of the trunk. It separates the thorax from the abdomen, constituting the floor of the former and the roof of the latter. All other muscles are placed on the outside of, or around, the levers which they are intended to move; but the diaphragm alone is situated within those levers, like the muscles of animals having an external skeleton.

Fig. 111.

The diaphragm divides the body into two unequal parts, an upper, or *supra-diaphragmatic*, and a lower, or *infra-diaphragmatic*. It is placed on the median line, but is not symmetrical. It is elliptical in form, its longest diameter being from side to side, thin and flattened, and resembles an arch, or rather a fan, the broad and circular portion of which is horizontal, whilst the narrow part is vertical, and at right angles to the former. The older anatomists, therefore, divided it into two portions; the upper, or *great muscle of the diaphragm*, and the lower, or *small muscle of the diaphragm*.

Attachments. It *arises* partly from the lumbar region of the vertebral column, in front of the bodies and intervertebral substances of the second, third, and fourth lumbar vertebræ, partly from the posterior surface of the sternum and the base of the ensiform cartilage; and partly from the posterior surface and upper edge of the cartilages and contiguous bony portions of the seventh, eighth, ninth, tenth, eleventh, and twelfth ribs. Sometimes it is attached also to the sixth rib.

ertebral origin consists of two tendons, formed by several smaller vertical situated in front of each other, which are blended with the anterior ligament of the spine. To these tendons two thick fleshy bundles which pass vertically upwards, become gradually thicker and broader, a fasciculus to each other, and are *inserted* into the posterior notch iponeurosis, having the form of a trefoil leaf, which forms the centre nuscle, and is therefore called the *central aponeurosis of the diaphragm* 11.), or *cordiform tendon*. These two fleshy bundles and their tendons e named the *pillars*, *crura*, or *appendices* of the diaphragm. The right interior, larger, and descends lower down than the left. Each pillar is ally divided into two very distinct secondary pillars, and the trace of sion is always visible in the opening which gives passage to the great iic nerve. The two pillars of the diaphragm leave between them an divided into two portions or rings, by the fleshy fasciculi which they y give to each other. The communicating fasciculus from the right anterior, and larger than that from the left. Of the two openings or tween the pillars of the diaphragm, the *lower* or *aortic* (*d*) is para- id gives passage to the aorta, the vena azygos, the thoracic duct, and es also to the left great sympathetic nerve. Like all orifices through arteries pass, it is aponeurotic in its structure, being formed by the of the pillars of the diaphragm at the sides, and above by a fibrous ation of those tendons which arches over and completes the ring:— er or *œsophageal* opening (*e*) gives passage to the œsophagus and the -gastric nerves; it is elliptical, and altogether muscular. In one sub- wever, I found the upper part tendinous; and in another a small mus- sciculus proceeded from the edge of the orifice, and was lost upon the the œsophagus. Haller has twice observed the same peculiarity.

rous prolongation proceeds outwards from the tendon of each crus, and to the base of the corresponding transverse process of the first lumbar a, so as to form an arch on each side (*fig.* 111.), under which the upper the psoas muscle passes (*ligamentum arcuatum proprium*). Another otic arch, which has been improperly called ligamentum arcuatum *it cintré du diaphragme*), for it is nothing more than the upper edge of rior layer of the aponeurosis of the transversalis muscle folded upon xtends from the outer extremity of the preceding arch to the lower and apex of the last rib; under it passes the superior portion of the us lumborum muscle (*fig.* 111.). From both these arches, muscular ass forwards, and are *inserted* into the corresponding part of the cordi- ndon. Indeed, the five tendinous arches which we have just described, aortic in the middle, and the two on each side for the psoas and us lumborum muscles, give origin to all the fleshy fibres which ter- at the posterior notch of the central tendon of the diaphragm. The e of these arches led Haller and Sœmmering to reckon three or four n each side. The cordiform tendon in which the preceding muscular re inserted, serves, in its turn, as the origin of other fibres which con- he vault of the diaphragm. This central aponeurosis (*b*), to which so nportance was attached by the ancients under the name of the *phrenic* ind which some modern anatomists regard as the central point of the poneurotic system of the human body, occupies the middle of the vault iaphragm, immediately below the pericardium, with which its circum- is blended in adults, but from which it may be easily separated in ubjects: it is a sort of aponeurotic island, surrounded on all sides by r fibres, and converting the diaphragm into a true digastric muscle. , it resembles a trefoil leaf, with a notch in the situation of the pedicle; rision is called a *wing*, or *leaflet*; the middle leaflet is the largest, the e next, and the left the smallest. Between the right and the middle s an opening (*f*), sometimes converted into a canal for the inferior va. This orifice is entirely tendinous, and of a quadrangular shape

when the vena cava is removed. It is bounded by four tendinous fasciculi which meet at right angles. The cordiform tendon is itself composed of several planes of fibres; the principal of which consists of a diverging series running forwards, and uniting into irregular, straight, or curved bundles, which intersect each other at various angles; an arrangement that gives great strength to the tendon. The fleshy fibres are attached to all points of the circumference of this tendon, and radiate from it in all directions. The anterior, very short, and sometimes aponeurotic, proceed to the base of the ensiform cartilage, describing a slight curve with the concavity directed downwards. A triangular interval, or else several small spaces, are often left between these fibres, establishing a communication between the cellular tissue of the thorax and that of the abdomen. Hence, diaphragmatic herniæ occasionally occur; and pus, formed in the neck or mediastinum, may ultimately point at the epigastrium. It is not uncommon to find the sternal attachment of the diaphragm partially or entirely deficient.

The lateral muscular fibres, which are much longer than the anterior, describe very well-marked curves, and form an arch with the concavity downwards, but more convex and projecting on the right than the left side. They then divide into six or seven digitations on each side, which are attached to the ribs, intersecting with the costal insertions of the transversalis abdominis. It is not uncommon to find considerable intervals between the digitations of this muscle, opposite which the pleura and peritoneum are in contact: this more especially occurs between the eleventh and twelfth ribs. The fasciculus for the twelfth rib is sometimes deficient, its place being occupied by a tendon. The *direction* of the fibres of the diaphragm is then *radiated* and *curvilinear* in the horizontal portion, but *radiated* and *rectilinear* in the vertical portion.

Relations. 1. The *inferior*, or *abdominal surface*, concave in the middle, and much more concave on the right side, where it corresponds to the convex upper surface of the liver, than on the left, where it is in contact with the spleen and the large extremity of the stomach, is covered by the peritoneum throughout the greater part of its extent, excepting at the situation of the coronary ligament of the liver, and also behind, where it is in relation with the third portion of the duodenum, the pancreas, the kidneys, the supra-renal capsules, and the solar plexus.

2. *Thoracic*, or *upper surface*. The middle portion is convex, and covered by the pleuræ and pericardium; it is flat, and serves as a floor to support the heart, the inferior surface of which rests upon it; hence the pulsations of the heart felt in the epigastrium. The lateral portions are convex, and contiguous to the lungs. The convexity is greater on the right than on the left side: the highest point to which the right side reaches in the natural condition is the level of the fourth rib; the highest point which the left side attains, is opposite the fifth rib. Hence the surgical rule of operating for empyema higher on the right than on the left side.*

The height to which the diaphragm is raised varies remarkably; it reaches very much higher in the fœtus than in the adult. Should the muscle be only slightly vaulted, it is considered by medical jurists as one of the presumptive proofs that the infant has respired.

3. *Circumference.* With the exception of the crura, the diaphragm is connected by its circumference only with one muscle, viz. the transversalis, which presents exactly corresponding attachments, so that, indeed, these two muscles may be considered as forming one contractile sac, interrupted by the costal insertions.

Action. The diaphragm forms an active septum between the thorax and

* This rule should be disregarded: the object of it is to open the thorax at the lowest part, so as to give a more easy exit to the liquid; but the lowest portion would be behind, in the deep groove formed by the diaphragm with the parietes of the thorax. It is of little importance to find the most depending part; it is sufficient to establish an outlet; the fluid will always flow to it.

abdomen, which affects the viscera of both cavities. The two pillars act like the long muscles; the body of the diaphragm after the manner of the hollow muscles. When the pillars contract, they take their fixed point upon the lumbar vertebræ, and their moveable point upon the notch at the back of the cordiform tendon, which is carried backwards and downwards. This aponeurosis in its turn becomes a fixed point for all the other curved radiated fibres that are attached to the ribs. The first effect of the contraction of a curved fibre is its becoming straight; and in this process the highest part of the curve is drawn down towards a level with its extremities: the vertical diameter of the thorax is therefore increased, and that of the abdomen proportionally diminished; but during contraction, the fibres act equally upon both their points of insertion, and as the cordiform tendon is fixed, and the costal attachments are moveable, the ribs are drawn inwards, and the transverse diameter of the thoracico-abdominal cavity thereby diminished. The antero-posterior diameter would be equally diminished, were it not for the inclination of the diaphragm downwards and backwards, in consequence of which the abdominal viscera are pressed downwards and forwards. Some experimentalists, among whom we may mention Haller and Fontana, have asserted that the diaphragm may become convex below during a forced contraction, but I believe this can only take place when air has been admitted into the cavity of the pleura.

We shall now consider the effects of the contraction of the diaphragm upon the openings by which it is perforated.

The elliptical or rather oval opening for the œsophagus, being entirely muscular, is contracted during the action of the diaphragm, in the same manner as the mouth by that of the orbicularis muscle: hence the œsophagus is compressed. From this it has been concluded that vomiting cannot take place during inspiration, but experience proves the contrary, vomiting being favoured by this compression.

It is generally said that the orifice for the vena cava is not affected by the contraction of the diaphragm; but if we draw upon the muscular fibres in the neighbourhood of this opening, we see at once that it is diminished in size; Haller has even witnessed this in a living animal during inspiration. The arch, or rather the parabolic canal, which gives passage to the aorta, is also contracted, and the vessel slightly compressed; hence doubtless arises the frequency of aneurisms of this artery, where it passes through the pillars of the diaphragm.

LUMBAR REGION.

The psoas and iliacus. — Psoas parvus. — Quadratus lumborum.

THE lumbar region includes the psoas and iliacus, the psoas parvus (when it exists), and the quadratus lumborum.

The Psoas and Iliacus.

I consider, that since the psoas and iliacus muscles have a common insertion, they should be described as a single muscle, having a double origin, which we shall term the psoas-iliac muscle.

Dissection. Having opened the abdomen, tear away with the fingers the peritoneum covering the iliac fossæ and the lumbar regions. Remove at the same time the intestines, the stomach, the pancreas, the kidney, the liver and the spleen; detach the iliac fascia. In order to see the femoral insertion of this muscle, divide the crural arch through the middle. Dissect with care the muscles at the anterior and superior part of the thigh, especially the pectineus, with which this muscle is in immediate relation. Remove the adipose cellular tissue, which surrounds the crural vessels and nerves.

The *psoas-iliac* muscle is deep seated, and extends from the sides of the vertebral column and front of the iliac fossa to the lesser trochanter of the femur. It *arises* above by two very distinct muscular masses; an internal, long, or

lumbar portion (lumbaris, sive psoas, *Riolanus*), the *great psoas* of authors; and an external, broad, or iliac portion, constituting the *iliacus* (iliacus internus, *Albinus*).

1. The *lumbar portion* (psoas magnus, from ψόαι, the loins, *g g*, *fig.* 111.), *arises* from the sides of the bodies of the five lumbar and last dorsal vertebræ, and of the corresponding inter-vertebral substances, and from the base of the transverse processes, by means of aponeurotic fibres, united by tendinous arches, which correspond to the grooves on the bodies of the lumbar vertebræ, so that the muscle is in reality only attached to the upper and lower borders of the bodies of the vertebræ, and to the inter-vertebral substances. From this double origin the fleshy fibres proceed in the form of a conoid bundle, compressed on the sides, and directed obliquely downwards and outwards; the summit of the cone is flattened, and embraced by the ligamentum arcuatum; the body is thicker and rounded, and diminishes in size inferiorly, as its constituent fibres are gradually attached to a tendon, which, though at first concealed in its centre, afterwards advances towards the anterior and external surface, receives the fibres of the iliacus, and is *inserted* into the lesser trochanter of the femur. The great psoas, therefore, resembles a double cone or spindle.

Its component fibres are not fasciculated, but are united by a very delicate cellular tissue. The complete absence of fibrous tissue explains the weakness of this muscle, which may be torn with the greatest facility, and perhaps also the frequency of its diseases. Its tenderness in the ox causes it to be a favourite joint for the table, under the name of short ribs (*aloyau*): perhaps this delicacy of texture is connected with the presence of a large plexus of nerves in the substance of the muscle.

2. The *iliac portion* (iliacus muscle; iliacus internus, *Alb.*, *i i*, *fig.* 111.) fills the internal iliac fossa. It *arises* from the whole of this fossa, from the crest of the ilium, the ilio-lumbar ligament, and the base of the sacrum, and from the anterior superior iliac spine, the notch below, the anterior inferior iliac spine, and even the capsular ligament of the hip-joint. The fleshy fibres converge, and are immediately attached to the external edge of the common tendon, which we have described as originating in the substance of the psoas. This tendon, which receives on its inner side all the fibres of the psoas, and even those fibres of the iliacus which arise from the brim of the pelvis, runs along the side of the brim, diminishing its transverse diameter, and emerges from the pelvis under the crural arch, passing through a remarkable groove between the anterior inferior spinous process of the ilium, and the eminentia ilio-pectinea. In this situation all the fibres of the psoas terminate; those that remain of the iliacus are successively attached to the outside of the tendon, like the barbs of a feather to the shaft, and form a triangular fleshy bundle which immediately changes its direction, passes backwards, inwards, and downwards, among the muscles of the thigh, turns slightly round so that its anterior surface looks somewhat inwards, and its posterior surface outwards, and is *inserted* into the lesser trochanter, which it embraces on every side, even to its base. It is not uncommon to find the fasciculus which comes from the anterior inferior spinous process of the ilium and the capsular ligament forming a very distinct muscle, which has been often described separately, under the name of the *ilio-capsulo-trochantericus;* it is inserted separately below the lesser trochanter into the oblique line which extends from this process to the linea aspera.

Relations. 1. The lumbar portion (*psoas magnus*) is in relation anteriorly with the diaphragm, the kidney, the ascending colon on the right side, the descending colon on the left, the peritoneum, and the psoas parvus when it exists. The external iliac artery and vein run along the anterior surface. On the inside it corresponds to the bodies of the lumbar vertebræ and the lumbar vessels; behind, to the transverse processes of the lumbar vertebræ and the quadratus lumborum. The lumbar plexus is situated posteriorly in the sub-

stance of the psoas magnus; this explains the violent pain in the loins experienced during repeated contractions of this muscle, and, during pregnancy, from the pressure of the gravid uterus. 2. The iliac portion lines the iliac fossa; it is covered by the peritoneum, the cæcum, and the end of the small intestines on the right side, and by the sigmoid flexure of the colon on the left. These two muscles form a projection on the inside, which reduces the transverse diameter of the brim of the pelvis from five inches to four and a half. 3. The psoas and iliacus exactly fill that portion of the crural arch in which they are placed, so that herniæ never take place in this situation. 4. In the thigh, the common tendon is separated anteriorly from the cellular tissue of the groin by the deep femoral fascia; it is in relation with the crural nerve which passes out of the pelvis in the same sheath as, but below, the psoas, in a groove between the latter and the iliacus, between which parts it forms the only separation. Behind, it is in contact with the anterior border of the os coxæ and the hip-joint, a large bursa intervening, which often communicates with the synovial capsule of the joint, by an opening of variable size.* The inner edge of the psoas-iliac muscle is in relation with the outer edge of the pectineus, and with the femoral artery, which it sometimes covers. The external edge is at first in relation with the sartorius, and afterwards with the rectus femoris. The psoas-iliac is also covered by the lumbo-iliac fascia (*fascia iliaca*), which will be described hereafter. (Vide APONEUROLOGY.)

Actions. The psoas-iliac muscle *flexes* the thigh upon the pelvis; this action is the more energetic from the fact of the fixed points of insertion being both on the vertebral column, and on the iliac fossa. The two portions of the muscle do not act in the same direction; but when they contract simultaneously, the opposite forces are destroyed, and the traction upon the common tendon becomes direct. This muscle affords a remarkable example of the reflexion of a muscle over a pulley, which greatly increases the power, by changing the direction of insertion nearly to the perpendicular. The action of this muscle, therefore, must only be calculated from the point of reflexion, *i. e.* the anterior edge of the ilium. It is in semi-flexion that the muscle becomes perpendicular to the femur, and acts with the greatest power; and, therefore, the *momentum* of the muscle occurs at that period. The psoas-iliac is at the same time a *rotator outwards* of the femur, on account of the obliquity of its insertion at the inner and back part of that bone. When the femur is fixed, as in standing, it draws the lumbar portion of the spine and the pelvis forwards; and its iliac portion rotates the pelvis so as to turn the front to the opposite side. When the muscles of each side act together, the trunk is inclined directly forwards.

The Psoas Parvus.

This muscle (*l l*, *fig.* 111.) lies in front of the preceding; it *arises* from the twelfth dorsal vertebra, the first and sometimes the second lumbar vertebræ, and the corresponding inter-vertebral substances. It forms a small flat bundle, at first appearing to be a dependence of the psoas magnus, but soon becoming isolated; it terminates in a broad, shining tendon which crosses the psoas magnus at a very acute angle, and is *inserted* into the upper part of the ilio-pectineal eminence, and the corresponding portion of the brim of the pelvis. This small muscle receives the lumbo-iliac aponeurosis (*fascia iliaca*), on its outer edge. It is often absent; we have sometimes seen it double. Its *use* is evidently to render the iliac fascia tense, and to tie down and prevent displacement of the lumbar portion of the psoas magnus. It may assist in flexing the pelvis upon the thorax, as in climbing; in the recumbent and supine position, if one muscle acts alone, it inclines the pelvis to its own side; but if its fixed point be below, it inclines the trunk to the same side.

* See note, p. 389.

The Quadratus Lumborum.

Dissection. Expose the posterior surface, by carefully detaching the common mass of the posterior spinal muscles; and to view the anterior, open the abdomen and remove the viscera. This muscle is inclosed in a sheath formed by the anterior and middle layers of the posterior aponeurosis of the transversalis abdominis; divide this sheath, and the muscle will be completely laid bare.

The *quadratus lumborum* (*m m*, *fig.* 111.) is quadrilateral in shape, and broader below than above; it is *situated* in the lumbar region, on the sides of the vertebral column, between the crest of the ilium and the last rib.

Attachments and direction. It arises from the ilio-lumbar ligament, and from about two inches of the adjacent part of the iliac crest, by aponeurotic fibres, which on the outer side especially are very long. These fibres are bound down by others, crossing them at right angles, and give origin to the fleshy part of the muscles, which proceeds upwards and a little inwards, in the following manner: — 1 Some of the fibres pass vertically upwards, and are *inserted* into the last rib, to an extent which varies in different individuals. 2. Others are directed very obliquely inwards, and divide into four fleshy bundles, *inserted* by means of a similar number of tendons into the summits of the transverse processes of the four superior lumbar vertebræ. 3. There is most commonly a third plane, anterior to the preceding, and consisting of fibres, which arise from the summits of the transverse processes of the third, fourth, and fifth lumbar vertebræ, and are *inserted* into the lower edge of the last rib.

Connections. The quadratus lumborum somewhat resembles the rectus abdominis, in being inclosed and bound down in a very strong tendinous sheath; it has therefore no direct relations. In front are the kidney, the colon, the psoas, and the diaphragm; behind, is the common mass of the spinal muscles, beyond which its outer border somewhat projects, especially below. Its most important relations are with the kidney and the colon. It is the guide for the necessary incisions in operations performed in this region, particularly in nephrotomy.

Action. With its fixed point at the crest of the ilium, this muscle depresses the last rib, by means of its costal insertions, thus acting as a muscle of expiration, and it inclines the spine to its own side, through the medium of its vertebral attachment. With its fixed point above, it inclines the pelvis to its own side.

LATERAL VERTEBRAL REGION.

The inter-transversales and rectus capitis lateralis. — Scaleni.

The lateral muscles of the vertebral column are the inter-transversales of the neck and loins, the rectus capitis lateralis, and the scaleni. The quadratus lumborum already described belongs also to this region.

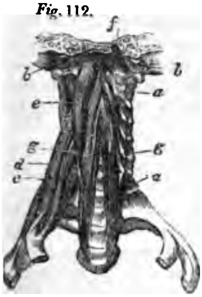
The Inter-transversales and Rectus Capitis Lateralis.

The inter-transversales muscles exist only in the neck and the loins; in the back, they are represented by the intercostals, an additional proof of the analogy between the ribs and the cervical and lumbar transverse processes. Many celebrated anatomists, however, admit the existence of inter-transverse muscles in the back, but they are nothing more than deep-seated fasciculi of the transverso-spinalis.

1. *Inter-transversales of the neck* (*a* to *a*, *fig.* 112.). There are two of these muscles in each inter-transverse space, an anterior and a posterior. They are small quadrilateral muscles, one arising from the anterior, the other from

he posterior margin of the groove on the transverse process below: from nese origins the fibres proceed vertically upwards, and are *inserted* into the transverse process of the vertebra above. They are separated from each other by the anterior branches of the cervical nerves, and by the vertebral artery, the canal for which they serve to complete. Behind, they are in relation with the posterior spinal muscles, the splenius, the levator anguli scapulæ, the transversalis colli, and the cervicalis descendens; and in part with the rectus capitis anticus major.

Fig. 112.



2. *Rectus capitis lateralis* (*b*, *fig.* 112.). This muscle may be regarded as the first posterior inter-transversalis of the neck, and the rectus capitis anticus minor, which we shall presently describe as the first anterior inter-transversalis. The comparative size of the rectus lateralis is not opposed to this view, for it is connected with the increased developement of the corresponding cranial vertebra. It *arises* from the transverse process of the atlas, and proceeds directly upwards to be inserted into the jugular surface of the occipital bone, immediately behind the fossa of that name. This muscle separates the jugular vein, with which it is in contact in front, from the vertebral artery to which it is contiguous behind.

3. *Inter-transversalis of the loins.* The absence of any groove upon the lumbar transverse processes would lead us at once to infer that in this region there must be only one muscle in each inter-transverse space. There are, therefore, five on each side. The first extends from the transverse process of the last dorsal to that of the first lumbar vertebra; and the last from the transverse process of the fourth to that of the fifth lumbar vertebra.

Action. These little muscles, by drawing the transverse processes towards each other, incline that portion of the vertebral column with which they are connected towards their own side; that is, the cervical muscles with the rectus lateralis incline the head and neck, and those of the lumbar region act upon the loins.

The Scaleni.

Dissection. These muscles are in a great measure displayed in the ordinary dissection of the anterior and posterior cervical regions. In order specially to expose them upon an entire subject, it is sufficient to dissect off the skin on the sides of the neck, and to remove the omo-hyoid, the nerves, the cellular tissue, and the sub-clavicular lymphatic glands. But in order to demonstrate the inferior attachments of these muscles, the upper limb must be scarified by disarticulating the clavicle at its sternal end, or still better by sawing the clavicle through the middle, dividing the great and small pectoral muscles, raising the sterno-cleido-mastoid, detaching the serratus magnus, and drawing the apex of the shoulder forcibly backwards.

The scaleni occupy the sides and lower part of the neck, extending from the two upper ribs to the six lower cervical vertebræ, sometimes to the atlas also. They are, therefore, fasciculated like all the other vertebral muscles. Anatomists are not agreed concerning their number. Albinus enumerated five on each side; Sabatier reduced these to three; but we agree with M. Boyer, and modern anatomists, in admitting the existence of two only, an anterior and a posterior. M. Chaussier has followed the example of Riolanus in describing only one, which he calls *costo-trachelien.*

1. The *scalenus anticus* (*c*, *figs.* 112, 113, and 114.) might be termed the *anterior long inter-transversalis colli.* Its name sufficiently indicates its triangular shape, though it rather resembles a cone with the base below, and the apex above.

Attachments and direction. It *arises* from the inner margin and upper surface of the first rib near its middle, the point of attachment being indicated by a tubercle, with which it is highly important that we should be acquainted, because it serves as a guide in placing a ligature upon the subclavian artery, which passes over the upper surface of the first rib. It arises by means of a tendon that expands into an aponeurotic cone, from the interior of which the fleshy fibres take their origin. These unite, form the body of the muscle, and proceed upwards and inwards, to be *inserted* by so many separate tendons into the anterior tubercles of the transverse processes of the sixth, fifth, fourth, and third cervical vertebræ, and more especially into the notches between the two tubercles at the extremities of these processes. It is not uncommon to find one or two fasciculi inserted into the posterior tubercles.

Relations. In front and on the outside this muscle is in relation with the clavicle, from which it is separated by the subclavian muscle and vein; higher up with the sterno-mastoid, the omo-hyoid, the phrenic nerve, and the transverse and ascending cervical arteries. *Behind*, it is separated from the posterior scalenus by a triangular space, which is wide below to receive the subclavian artery, and narrow above, where it corresponds to the brachial plexus of nerves, by the first two branches of which the muscle is sometimes perforated. On the *inside* it is separated from the vertebral artery by the longus colli. The relations of the scalenus anticus to the subclavian vein and artery are of the highest importance to the surgeon, and in order to impress them upon the memory I propose to designate it *the muscle of the subclavian artery*. I have seen both the artery and vein placed in front of this muscle.

The *scalenus posticus* (*d*, *figs.* 112, 113, and 114.) may be termed the *posterior long inter-transversalis colli*. It is situated behind the preceding muscle, is of the same shape, but somewhat larger.

Attachments and direction. It has two perfectly distinct origins; one, anterior and larger, from all that part of the first rib intervening between the depression for the subclavian artery and the tubercle; and another, posterior, from the upper edge of the second rib. The latter attachment is sometimes wanting. Proceeding from this double origin, the fleshy fibres form two small muscular bodies, which either remain distinct, or become blended together, and pass upwards and inwards, to be inserted by six separate tendons into the posterior tubercles of the transverse processes of the six inferior cervical vertebræ. It is not uncommon to find a fasciculus extending from the second rib to the atlas.

Relations. It is separated from the anterior scalenus by the subclavian artery and brachial plexus; and is in relation, behind, with the cervicalis descendens, transversalis colli, splenius, and levator anguli scapulæ: on the outside, with the serratus magnus, the transverse cervical artery, and the sterno-mastoideus: on the inside, with the first intercostal, the first rib, the inter-transversales of the neck, and the cervical vertebræ.

Action The scaleni are powerful flexors of the neck, when their fixed points are below; but when their upper attachments are fixed, they tend to elevate the first rib, and in a slight degree the second also.

DEEP ANTERIOR CERVICAL, OR PREVERTEBRAL, REGION.

The recti capitis antici, major et minor.—Longus colli.—Action of these muscles.

This region includes three pairs of muscles placed immediately in front of the cervical and three superior dorsal vertebræ, viz. the *rectus capitis anticus major*, the *rectus capitis anticus minor*, and the *longus colli*. Their arrangement is extremely complicated and very difficult of elucidation, unless we consider them in the same general manner already adopted with regard to the disposition of the posterior spinal muscles. Let us suppose, then, that there exists in the median line of the basilar process of the occipital bone and the anterior surface of the bodies of the cervical vertebræ, a series of spinous processes (a supposition which is realised in some animals), then the rectus

nticus major would be a *transverso-spinalis*, the rectus minor an *an-ter-transversalis* between the occipital bone and the atlas, and the colli would be a compound muscle, its lower fibres forming a *spino-alis*, its upper fibres a *transverso-spinalis*, and its internal fibres a

All this will be rendered apparent from the following description.

ction. Remove the face and all the parts which cover the cervical of the spine by the vertical section, called the *section of the pharynx*, it is also employed in demonstrating that part. In order to separate from the cranium, remove the roof of the skull by a horizontal section, n make a vertical cut either from above or from below; if we cut from ve may adopt the usual plan of directing the saw transversely, so as to immediately in front of the auditory meatus: in doing this, however, n danger of injuring the superior attachments of the recti, or of cut-o the pharynx. We prefer, therefore, the following method: make ions with the saw obliquely forwards and inwards in the course of the -mastoid and petro-occipital sutures, and having arrived at the basilar cut it across with a chisel, a little in front of the anterior condyloid a. In separating the face from the cranium from below upwards, a mber of muscles must be scarified: the preceding section is therefore le, although it is somewhat more difficult.

The Rectus Capitis Anticus Major.

muscle (*e*, *figs.* 112. and 114.), the transverso-spinalis anterior (rectus nternus major, *Alb.*), is the most external of those in the prevertebral

hments and direction. It *arises* from the anterior tubercles of the se processes of the sixth, fifth, fourth, and third cervical vertebræ, by ndons to which as many fleshy fasciculi succeed; these pass obliquely s and inwards, overlying and blending with each other, and terminate posterior surface and edges of a shining aponeurosis, that occupies entirely the anterior aspect of the muscle. This aponeurosis itself be-surface of origin, dividing into two laminæ, from the borders of and between which a fleshy bundle ascends, to be inserted into the basilar in front of the foramen magnum. The fasciculus arising from the ervical vertebra does not join the common insertion, but is attached and in a very distinct manner to the basilar process within and behind mon fasciculus. The muscle must be turned outwards, in order to this structure.

ions. It is covered by the pharynx, the internal carotid artery and vein, the superior cervical ganglion and trunk of the great sympathetic nd the par vagum, being separated from all these parts by some loose tissue and the prevertebral aponeurosis. It covers the corresponding e, the articulation of the occipital bone with the atlas, and that of the th the axis, a portion of the longus colli, and also of the rectus minor.

The Rectus Capitis Anticus Minor.

muscle (*f*, *fig.* 112.), the inter-transversalis anterior (rectus capitis in-minor, *Alb.*), extends from the base of the transverse process and from cent part of the lateral mass of the atlas, to the basilar process of the l bone. It is partially covered by the rectus major, which is nearer ial plane: the superior cervical ganglion of the sympathetic rests upon t covers the atloido-occipital articulation. It may be regarded as an inter-transversalis between the occipital bone and the atlas, the rectus constituting the posterior inter-transversalis.

The Longus Colli.

Attachments, direction, and relations. The longus colli (*g g, figs.* 112. and 114.) as before stated, is composed of three very distinct sets of fasciculi: 1. the *transverso-spinalis*, which, *arising* by flat tendons from the anterior tubercles of the transverse processes of the fifth, fourth, and third cervical vertebræ, unite so as to form a considerable fleshy bundle directed upwards and inwards, occupy the hollow on each side of the median line of the axis, and are *inserted* into the anterior tubercle of the atlas, which may be regarded as the representative of an anterior spinous process; 2. The *anterior spino-transversalis*, the least numerous of all, *arise* from the bodies of the three superior dorsal vertebræ by very slight tendinous expansions, proceed upwards and outwards, and are *inserted* into the anterior tubercles of the transverse processes of the fourth and third cervical vertebræ; 3. The spinalis which *arise*, to the inner side of the preceding fasciculi, from the bodies of the three upper dorsal and four lower cervical vertebræ, and from the intermediate ligaments, and having described a slight curve, are inserted into the crest of the axis, and into the third cervical vertebra. The longus colli is elongated and fusiform in shape; it supports the pharynx, the œsophagus, the internal carotid artery, the internal jugular vein, and the pneumogastric and great sympathetic nerves: it covers the vertebræ to which it is attached.

Action of the Muscles of the deep Anterior Cervical Region.

When the head is thrown back, these muscles restore it to its original position. The rectus anticus major tends to flex the head, and from its obliquity to rotate it, so as to turn the face to its own side. The rectus minor inclines the head to its own side. The longus colli flexes the atlas upon the axis, and rotates it so as to turn the face to its own side. The same muscle also rotates the lower part of the neck, so as to turn the face to the opposite side; and, lastly, it is a direct flexor of the cervical region.

THORACIC REGION.

The pectoralis major. — Pectoralis minor. — Subclavius. — Serratus magnus. — Intercostales. — Supra-costales. — Infra-costales. — Triangularis sterni.

The Pectoralis Major.

Dissection. Separate the arm from the side. Make a horizontal incision from the top of the sternum to the front of the arm on a level with the lower border of the axilla, including in this incision a fascia, which adheres closely to the fleshy fibres. Reflect one of the flaps upwards and the other downwards, by dissecting parallel to the fibres, *i. e.* transversely to the axis of the body.

The *pectoralis major* (*c c, fig.* 109.), is a broad thick triangular muscle, situated at the upper and fore part of the thorax and axilla. It *arises* from the anterior border of the clavicle and anterior surface of the sternum, from the cartilages of the second, third, fourth, and more particularly those of the fifth and sixth ribs, from the osseous portion of the last mentioned rib, and from the abdominal aponeurosis: it is *inserted* into the anterior margin of the bicipital groove of the humerus.

The *clavicular origin* consists of short tendinous fibres attached to the entire breadth of the anterior border of the clavicle, for about the inferior third, or half of its extent.

The *sternal attachment* consists of aponeurotic fibres, which, intersecting with those of the opposite muscle, form, in front of the sternum, a very thick fibrous layer, sometimes almost completely covered by the muscular fibres, which, in certain individuals, advance nearly to the median line.

The *costal origins* consist of very thin tendinous laminæ, and the attachment to the abdominal aponeurosis is blended with that of the rectus abdominis.

From these different origins the fleshy fibres proceed *outwards* in different directions; the upper fibres obliquely *downwards*, the middle *transversely*, and the lower fibres *obliquely*. These last are *folded* backwards, so as to form a sort of groove, which embraces the lower border of the pectoralis minor. It appears, then, that the pectoralis major is composed of three very distinct portions, which are sometimes separated by a greater or less quantity of cellular tissue. These three portions in converging are so disposed, that the upper overlaps the middle, and this again the lower portion, the fibres of which are twisted upon themselves, so that the lowest in front become the highest behind, and vice versâ.* They are all inserted into the anterior lip of the bicipital groove by means of a flat tendon, about fifteen lines in breadth, which is continuous with the anterior edge of the tendon of the deltoid. The structure of this tendon commands particular attention, and can only be examined after having divided the muscle across, and turned the external half outwards. It will then be seen that it is composed of two laminæ, placed one before the other, sometimes blended together, but generally distinct, or united only by their lower edges, so that they form a groove opening upwards. The anterior lamina is the thicker, and receives the clavicular and middle portions of the muscle; the deep layer affords attachment to the lower portion. It is not uncommon to find the two laminæ separated by the tendon of the long head of the biceps, the groove for which they then contribute to form. The entire tendon is broader and thicker below than above, and gives off, both forwards and backwards, an aponeurotic expansion, constituting one of the chief origins of the fascia of the arm.†

Relations. It is covered by the platysma myoides, the mammary gland, and the skin. Its deep relations are of the greatest importance. On the *thorax*, it covers the sternum, the ribs and their cartilages, the pectoralis minor, the subclavius nauscle, the serratus magnus, and the intercostals. It forms the anterior wall of the axilla, and is in relation with the brachial plexus and axillary vessels, and with the cellular tissue and lymphatic glands of that region. Its *external border* is nearly parallel to the anterior edge of the deltoid, being separated from the latter by a linear or triangular cellular interval, in which are situated the cephalic vein and acromial artery. Its *lower border* is thin towards the median line, thick and tendinous externally; it forms the anterior border of the axilla, and gives rise to a projection under the skin, proportionate to the developement of the muscle. Its *inner border* intersects in the median line with the muscle of the opposite side, and is continuous below with the linea alba.

Uses. The pectoralis major is essentially an *adductor of the arm;* at the same time it rotates it inwards, and draws it forwards. It is by the action of this muscle that the forearms are crossed, and that one hand is placed on the opposite shoulder. Its upper or clavicular portion conspires with the anterior fibres of the deltoid and with the coraco-brachialis in elevating the humerus and carrying it forwards.

If the arm be at a moderate distance from the side and its lower extremity be fixed, as is the case in falling on the elbow when the arm is directed outwards, this muscle acts upon the humerus as upon a lever of the third order, of which the fulcrum is below, the power in the middle, and the resistance above, and it then tends to dislocate the head of the humerus with great force, because in this position its insertion is perpendicular to the lever.

When the humerus is fixed, the pectoralis major acts upon the ribs, the

* I believe that this overlapping and folding of the muscular fibres tend reciprocally to prevent the displacement of any individual portion of the muscle.

† I have once observed a very slender muscular fasciculus, arising from the abdominal aponeurosis, proceed along the inferior border of the pectoralis major, from which it was perfectly distinct, and terminate in a small tendon opposite the humeral insertion of that muscle. This tendon was continued along the inner side of the arm, adhered to the aponeurotic inter-muscular septum, from which it received a small fleshy fasciculus, and was ultimately inserted into the epitrochlea.

sternum, and the clavicle, and raises the trunk upon the arm. It is therefore one of the chief agents in climbing. Its action upon the ribs renders it an important auxiliary in cases of laborious inspiration. Hence the attitude of an asthmatic patient, who always places himself so as to keep the humeri fixed.

The Pectoralis Minor

Dissection. Detach the clavicular insertion of the pectoralis major, and divide that muscle in the middle by a vertical incision; reflect the two flaps, taking care to remove, at the same time, the loose cellular tissue which invests its deep surface.

The *pectoralis minor* (*e*, *fig.* 110.) is a thin, flat, triangular muscle, having its internal edge serrated (serratus anticus, *Albinus*), and occupying the anterior and upper part of the thorax and shoulder. It *arises* from the third, fourth, and fifth ribs by three delicate, shining, tendinous prolongations, lying superficially to the intercostal muscles; to these succeed three fleshy fasciculi, which unite and converge, so as to be *inserted* by a flat tendon into the anterior margin of the coracoid process near its summit.

Relations. It is covered by the pectoralis major, from which it is separated by the thoracic vessels and nerves: its posterior surface is in relation with the ribs, the intercostal muscles, the serratus magnus, the cavity of the axilla, and therefore with the axillary vessels and nerves. This last relation is of great importance, and sometimes renders the section of this muscle necessary for the ligature of the axillary artery. Attention should also be directed, 1. to its upper border, which is separated from the clavicle by a triangular interval, broad on the inside and narrow on the outside, in which the same artery may be tied; and 2. the lower border of the muscle extends downwards beyond the pectoralis major.

Action. Most commonly it acts upon the scapula (musculus qui scapulam antrorsum agit, *Vesalius*). With its fixed point at the ribs, it evidently draws the scapula forwards and downwards, and forcibly depresses the apex of the shoulder. As a *depressor of the shoulder*, it acts in conjunction with the levator anguli scapulæ and rhomboideus, but antagonises those muscles considered as elevators of the entire scapula: it is also opposed to the rhomboideus when moving the scapula forwards. With its fixed point at the scapula, this muscle *elevates the ribs* to which it is attached.

The Subclavius.

Dissection. Raise the clavicle by carrying the apex of the shoulder upwards; divide the pectoralis minor, and remove the fibrous membrane, descending from the clavicle, and immediately investing the muscle. In order to expose its external or clavicular insertion, saw through the clavicle in the middle; divide the muscle at the same point, and reflect the external half with the corresponding portion of the clavicle.

The *subclavius* (*g*, *fig.* 110.) is a long, thin, fusiform muscle, applied to the lower surface of the clavicle, by which it is concealed (musculus qui sub clavicula occultatur, *Fabricius Hildanus*). It *arises* from the cartilage of the first rib, and is inserted into the inferior and external surface of the clavicle. Its costal attachment consists of a cervical tendon, from which the fleshy fibres proceed outwards, backwards, and upwards, and are inserted into the clavicle by short tendinous fibres.

Relations. It is covered above by the clavicle, which is grooved beneath for its reception; it is in relation below with the first rib, being separated from it by the axillary vessels and the brachial flexus; in front, it is enveloped by a very strong aponeurosis completing the osteo-fibrous canal in which it is included. Its relation with the brachial plexus and axillary vessels prevents the direct

compression to which these parts would have been otherwise exposed between the clavicle and the first rib.

Action. When its fixed point is at the first rib it depresses the clavicle, and is, therefore, a *depressor of the shoulder;* it tends also to press the inner end of the clavicle forcibly against the sternum; so, also, in fracture of the clavicle it occasions the external fragment to ride upon the internal. When its fixed point is at the clavicle, it assists in elevating the first rib, and is, therefore, arranged among the muscles that act in impeded inspiration.

The Serratus Magnus.

Dissection. Having removed the two pectorals, saw through the clavicle at its middle; press the scapula backwards, directing its axillary edge outwards; remove with care the cellular tissue occupying the axilla, especially that against the axillary vessels and nerves, and near the costal attachments of the muscle itself, in order to see the internal surface of which the subject must be turned, and the vertebral costa of the scapula drawn outwards.

The *serratus magnus* (*u*, *fig.* 106., *d*, 109., and *l*, 110.), very broad, quadrilateral, and serrated along one of its borders, occupies the side of the thorax, and extends like a muscular girth from the ten upper ribs to the vertebral costa of the scapula. Its *costal attachments* consist of nine or ten digitations arranged in a curve, having its concavity directed backwards. The first digitation, which is very large, arises both from the first and second ribs, and from an aponeurotic arch between them; from thence the fibres proceed upwards, outwards, and backwards, and are inserted into the inner surface of the posterior and superior angle of the scapula, near the levator anguli. This digitation is the narrowest part of the muscle; it differs in direction from the remainder, and is separated from them by a cellular interval; hence it has been termed the *superior portion of the serratus magnus.* The second, third, and fourth digitations *arise* in an oblique line, running downwards and forwards from the second, third, and fourth ribs. These are the largest and the thinnest of all the digitations; they proceed horizontally backward, and are *inserted* separately by short tendinous fibres into the entire length of the vertebral costa of the scapula, anterior to the rhomboid; they are distinguished from the remaining digitations both by their direction, and by an intervening cellular space; they form the *middle portion of the serratus magnus.*

The fifth, sixth, seventh, eighth, ninth, and tenth digitations arise from the outer surface of the corresponding ribs along oblique lines, resembling the fingers crossed, and are interposed between corresponding prolongations of the external oblique. These digitations are at first tendinous, they soon become fleshy, and converging towards each other form a radiated fasciculus, which passes upwards, outwards, and backwards, to be inserted into the internal surface of the inferior angle of the scapula. This is the *inferior portion of the serratus magnus.*

Relations. The serratus magnus is partially covered by the two pectorals before, by the subscapularis behind, and above by the axillary vessels and nerves; its deep surface rests upon the ribs and the intercostal spaces, all these parts being united by a quantity of loose cellular tissue. A considerable portion of the lower part of the muscle is subcutaneous, and therefore the inferior digitations are important studies for the painter and the sculptor, and sometimes even for the surgeon, as indications of the arrangement of the corresponding ribs.

Action. From the disposition of its different fasciculi, the serratus magnus occasions a compound movement of the scapula, which it will be well to analyse. The upper portion depresses and brings forwards the apex of the shoulder; the middle portion draws the entire scapula directly forwards; whilst the lower portion depresses it, and moreover rotates it, so that the apex of the shoulder is carried upwards. As the lower part of the muscle is composed of

six or seven of the converging fasciculi, which act with greater energy than the others, it follows that their action predominates even when the whole muscle contracts. The serratus magnus is then a *depressor of the entire shoulder* and an *elevator of its apex*. It is more especially concerned than any other muscle in supporting a burden upon the shoulder.

In order that the action of the serratus may be directed upon the scapula, its costal attachments must be fixed: this requires the simultaneous contraction of the oblique muscles of the abdomen to maintain the ribs in a depressed position, and of the diaphragm and transversalis to prevent their projection outwards. This simultaneous contraction occurs during all great efforts.

When the fixed point of the serratus magnus is at the scapula, its upper portion becomes a muscle of inspiration, its middle one of exspiration, and its lower one of inspiration. The greater power of the latter has been the cause of the antagonising action of the middle portion being overlooked; and the serratus magnus is, with great justice, regarded as the most powerful accessory muscle of inspiration: hence the various attitudes of asthmatic persons, who instinctively take a position which fixes the scapula, either by seizing a cord suspended from the top of the bed, or by bending forwards, and leaning on their elbows and forearms, or by resting their upper extremities on two lateral supports.

The Inter-costales, Externi and Interni; the Supra-costales and the Infra-costales.

Dissection. In order to examine the external intercostals, and the supra-costales (levatores costarum), the scapula and all the muscles which cover the thorax must be removed; to expose the internal inter-costales and the infra-costales, it is necessary to saw through the middle of the dorsal vertebræ and the sternum in a vertical direction, and to tear off the pleura from one side of the thorax, which may be very easily accomplished by the fingers.

The *intercostal muscles*, as their name implies, occupy the intervals between the ribs: there are two in each intercostal space, and therefore as many pairs as there are spaces.

They are divided into *external* and *internal*. They represent two very thin muscular layers, of exactly the same width as the spaces to which they belong; taken together, they also occupy the entire length of those spaces, but not separately, for the external intercostals extend only from the costo-vertebral articulations to the commencement of the cartilages of the ribs, while the internal intercostals commence at the angles of the ribs behind, and extend forwards to the sternum. A very thin aponeurosis is prolonged from the free margin of the one forwards and of the other backwards to the end of the intercostal space. The external muscles, which I have generally found thicker than the internal, *arise* from the lip of the groove on the lower border of one rib, and the internal from the inner lip of the same groove, as well as from the corresponding costal cartilage; they are both *inserted* into the upper border of the rib below. The superior attachments consist of fleshy and tendinous fibres and lamellæ, all of which proceed downwards to the rib below; those of the external layer obliquely forwards, and those of the internal layer much less obliquely backwards. The inferior attachments are similar in structure. The tendinous fibres of the intercostal muscles are very long, and much more numerous than the fleshy fibres: hence the intercostal spaces possess considerable strength, to which the crossing of the two layers also contributes.

Relations. The external intercostals are covered by the two pectorals, the serratus magnus, the serrati postici, the latissimus dorsi, the sacro-lumbalis, and the external oblique; they are superficial to the internal intercostals, and are separated from them by the intercostal vessels and nerves, and by a very thin fibrous layer. The internal intercostals are covered by the external and

by the aponeurotic layer continuous with them anteriorly. Internally they are in relation with the pleura, which from the angles to the tuberosities of the ribs is in apposition with the external muscles.

The *infracostal* muscles of Verheyen consist of small muscular and aponeurotic tongues, variable in number and length, which extend from the inner surface of one rib to the inner surface of the next, and sometimes also to the second or third rib below. They are sometimes vertical, but often oblique, like the internal intercostals, of which they may be regarded as portions.

Supra-costales (levatores breviores costarum of *Albinus*, *o* to *o*, *fig.* 107.). These are small triangular muscles, situated at the back part of the intercostal spaces. They are accessories of the external intercostals, resemble them in being half tendinous and half fleshy, and appear to form a continuation of them. There are twelve on either side. Each *arises* from the summit of the transverse process of a vertebra, and proceeds in a radiated manner downwards, to be *inserted* into the back part of the upper border and external surface of the rib below.

The fibres of these muscles have the same direction as those of the external intercostals, but they are more oblique, especially on the outside. The first arises from the transverse process of the seventh cervical vertebra, the last from that of the eleventh dorsal. Some of these muscles have two digitations, one disposed in the ordinary manner, the other attached to the next rib below. The latter, called the *long supracostals* (levatores longiores, *Albinus* and *Haller*), form a transition between the levatores breviores and the serrati. Morgagni met with all the levatores united together, so as to form a very regular serrated muscle. They are covered by the longissimus dorsi and sacro-lumbalis, and they cover the external intercostals.

Action. The contraction of the intercostal muscles tends to approximate the ribs; and according as the upper or the lower ribs are fixed, they act as muscles of inspiration or of expiration. It has never been denied that the external intercostals are muscles of inspiration, but the crossing of the two muscular layers has given rise to the opinion that they oppose each other in action; and hence arose the celebrated dispute between Hamberger and Haller. It is easy to understand that the slight difference existing between their attachments, with regard to their distance from the fulcrum, could not counterbalance the effect of a difference in the relative fixedness of the ribs, and that the intercrossing of these muscles has no other object than to increase the strength of the parietes of the thorax.

As the first rib is much more fixed than the last, it follows that it must serve as a fixed point for the first intercostal muscle, which will consequently raise the second rib; this will then become the fixed point for the third rib, and so on. The scaleni often take their fixed point upon the vertebræ, and then assist in elevating the first rib. The quadratus lumborum depresses the last rib, which may then serve as a fixed point for the others during expiration.

The levatores act very effectually in raising the ribs; for being attached so near to the fulcrum, the slightest movement produced in the posterior extremity of the rib becomes very sensible at the other end. I agree with Borelli (*De Motu Animal.* tom. ii. p. 158.) that the intercostals act even during the most easy respiration. This can be observed upon our own persons, and also in individuals in deep sleep. The ribs will be seen distinctly carried outwards, and the sternum raised.

The Triangularis Sterni, or small Anterior Serratus.

Dissection. Divide the ribs vertically at their junction with the cartilages, and tear off the pleura with the fingers.

The *triangularis sterni* represents the levatores costarum in front, or rather the serrati postici, with this difference, that it occupies the internal instead of

the external surface of the thorax. Like them it is serrated. It *arises* from the sides of the posterior surface of the sternum from the ensiform cartilage and the inner ends of the cartilages of the ribs. From this origin the fleshy fibres proceed, dividing into three, four, five, and sometimes six digitations, which are inserted by tendinous fibres into the posterior surface and borders of the sixth, fifth, fourth, third, sometimes of the second, and even of the first costal cartilages. The lower fibres pass horizontally and parallel to the upper fibres of the transversalis with which they are continuous. The succeeding *fibres* are directed upwards and outwards, proceeding more and more obliquely upwards: hence the triangular shape of the muscle, to which its name refers.

Relations. It is covered by the sternum, the internal intercostal muscles, and the costal cartilages, from which it is separated by the mammary vessels and some lymphatic glands; it is lined internally by the pleura, and rests upon the diaphragm below.

Its *use* is evidently to depress the costal cartilages into which it is inserted, or to oppose their elevation.

Remarks concerning the intercostal muscles. The muscles we have just described, viz. the intercostals and their accessories, are essential elements in the construction of the chest; they are found in all animals possessed of a thorax. Their use is to dilate and contract this cavity in its antero-posterior and transverse diameters. The first rib, being fixed by the contraction of the scaleni, serves as a fulcrum for the agents of inspiration; and the last rib, when fixed by the quadratus lumborum, serves the same purpose for those of expiration; so that these muscles, whose most common action is to incline to one side the neck and the loins, do not, on that account, act the less upon the ribs. I cannot, by any means, agree with Winslow, who denies that the scaleni have any action upon the ribs; and maintains that the articulation of the first rib with the first dorsal vertebra, is intended for the movement of the vertebra on the rib, not for that of the rib on the vertebra. (Winslow, *Expos. Anat.* t. ii. p. 360.)

SUPERFICIAL ANTERIOR CERVICAL REGION.

The platysma myoides.— Sterno-cleido-mastoideus.

The Platysma Myoides.

Dissection. Stretch the muscle by inclining the head backwards and placing a block under the shoulders of the subject; make a horizontal incision through the skin from the angle of the jaw to the symphysis menti, another from the symphysis to the inner end of the clavicle, and a third along the clavicle. These incisions should be very superficial, scarcely dividing the entire thickness of the skin. The muscle must be very cautiously dissected by taking care to commence at its upper part, to turn the edge of the scalpel towards the skin, and to follow exactly the direction of the fleshy fibres which pass obliquely downwards and outwards.

The *platysma myoides* (*e, fig* 109.), called *le peaucier* by Winslow, *latissimus colli* by Albinus, is a broad, very thin, and irregularly quadrilateral muscle lining the skin at the forepart of the neck, and adhering to it like the cutaneous muscles of the lower animals. It extends from the skin covering the anterior and upper part of the thorax to the side of the face, where it terminates thus, — at the base of the lower jaw, at the commissure of the lips, upon the masseter muscle, and at the skin of the face. From its lower attachment, which is almost always prolonged as far as the shoulder, and loses itself in the subcutaneous cellular tissue, the fibres proceed obliquely upwards and inwards; the pale muscular fasciculi which they form are separated from each other, and sometimes strengthened by additional fasciculi to the posterior border of the muscle: they terminate in the following manner above: — the posterior fibres are lost under the skin of the face near the masseter muscle, the lower

end of which they cover; those next in front are partly continuous with the triangularis oris, and partly with the quadratus menti; the anterior fibres terminate at the external oblique line of the lower jaw, and the most internal intersect with those of the opposite side. The posterior fibres, which are lost upon the skin of the face, are the rudiments of a remarkable fasciculus, an accessory of the platysma, found in some subjects. It is directed obliquely downwards from the region of the parotid gland to the angle of the lips. Santorini described it under the name of *risorius novus*.

Relations. These two muscles occupy the whole anterior region of the neck, excepting the median line, where they leave a triangular interval, having its base below, and occupied by a very dense fibrous tissue, forming a species of raphé, which is found in the median line throughout the body. This is the *linea alba* of the neck, from which the different component layers of the cervical fascia take their origin.

The platysma is intimately connected with the skin, but it does not adhere equally throughout; it is united closely below, but much more loosely above, where the intervening cellular tissue is always adipose, and capable of containing a large quantity of fat, as we find in individuals who have what is called a double chin. There are no lymphatic glands between this muscle and the skin; they are all situated beneath the muscle. The relations of the deep surface of the platysma are very numerous. It covers the supra and sub-hyoid, and the supra-clavicular regions, being separated from all the structures beneath it by the cervical fascia, to which it is united by loose cellular tissue, seldom containing any fat. If we examine these relations in detail, we find, proceeding from below upwards, that it covers, 1. the clavicle, the pectoralis major, and the deltoid; 2. In the neck, the external jugular vein, and also the anterior jugulars where they exist, the superficial cervical plexus, the sterno-mastoid, the omo-hyoid, the sterno- or cleido-hyoid, the digastric, and the mylo-hyoid muscles, the sub-maxillary gland, and the lymphatic glands at the base of the jaw. In front of the sterno-mastoid, it covers the common carotid artery, the internal jugular vein and the pneumogastric nerve; behind the sterno-mastoid, it covers the scaleni muscles, the nerves of the brachial plexus, and some of the lower nerves of the cervical plexus. 3. In the face, it covers the external maxillary or facial artery, the masseter, and buccinator muscles, the parotid gland, &c.

Action. The platysma is the most distinctly marked vestige in the human body of the panniculus carnosus of animals; and it can produce slight wrinkles in the skin of the neck. Its anterior border, especially at its insertion near the symphysis menti, is the thickest part of the muscle, and therefore projects slightly during its contraction. It is one of the depressors of the lower jaw; it also depresses the lower lip, and slightly the commissure of the lips. It therefore assists in the expression of melancholy feelings, but it is antagonised by the accessory portion, which draws the angle of the lips upwards and a little outwards, and thus concurs in the expression of pleasurable emotions; hence its name, *risorius*.

The Sterno-cleido-mastoideus.

Dissection. Divide the skin and the platysma from the mastoid process to the top of the sternum, in an oblique line, running downwards and forwards, reflect the two flaps, one forwards and the other backwards, taking care to remove at the same time the strong fascia which covers the muscle. In order to obtain a good view of the superior attachments, make a horizontal incision along the superior semicircular line of the occipital bone.

The *sterno-cleido-mastoid* (*b*, *fig.* 113.) occupies the anterior and lateral regions of the neck. It is a thick muscle, bifid below, and narrower in the middle than at either end. It *arises* by two very distinct masses, from the inner end of the clavicle, and from the top of the sternum in front of the four-

chette, and is inserted into the mastoid process and the superior semicircular line of the occipital bone. The sternal origin consists of a tendon prolonged for a considerable distance in front of the fleshy fibres. The clavicular origin consists of very distinct parallel tendinous fibres, attached to the inner side of the anterior edge, and upper surface of the clavicle, to a very variable extent, an important fact in surgical anatomy. There is often a considerable cellular interval between these two origins: sometimes this interval scarcely exists, but in all cases the two portions of the muscle can be readily separated. From this double origin the fleshy fibres proceed, forming two large bundles which remain distinct for some time. Many anatomists therefore, Albinus in particular, have considered it as consisting of two separate muscles, which they describe as the *sterno-mastoid*, and the *cleido-mastoid;* a division that is sanctioned by the comparative anatomy of this muscle. The sternal portion of the muscle is the larger, and passes upwards and outwards; the clavicular portion proceeds almost vertically upwards, behind the other, and is entirely concealed by it at the middle of the neck; the two portions still remain separate, although approximated; ultimately they become united, and are inserted into the apex and anterior surface of the mastoid process by a very strong tendon, which runs for some distance along the anterior border of the muscle, and also into the two external thirds of the superior semicircular line of the occipital bone, by a thin aponeurosis. The *direction* or axis of the sterno-mastoid passes obliquely upwards, backwards, and outwards.


Fig. 113.

The *relations* of this muscle are very important. Its *superficial* or *external* surface is covered by the skin and platysma, from which it is separated by the external jugular vein, and the branches of nerves, constituting what is improperly termed the superficial cervical plexus. Its *deep* or *internal surface* covers,—1. the sterno-clavicular articulation; 2. all the muscles of the subhyoid region, and also the splenius, the levator anguli scapulæ, the digastricus, and the scaleni; 3. the accessory nerve of Willis, which crosses beneath its superior third, the pneumo-gastric nerve, the great sympathetic, the loop of the hypoglossal nerve, and the cervical nerves; 4. the internal jugular vein; 5. the lower portion of the common carotid artery. Its *anterior border* produces a ridge under the skin, which it is important to study, because the first incisions for ligature of the common carotid, and for œsophagotomy, should be made along it. The parotid gland rests upon the upper part of this border, which is separated from the corresponding border of the muscle of the opposite side by a triangular interval, of which the apex is below, and the base above. Its *posterior* border forms the anterior limits of the lateral triangle of the neck, which is bounded behind by the external margin of the trapezius, and below by the clavicle.

Action. When the sterno-cleido-mastoid of one side acts alone, it flexes the head, inclines it to its own side, and rotates it so that the face is turned to the opposite side. It is therefore both a *flexor* and a *rotator of the head.* When

both muscles act together, they flex the head directly upon the neck, and the neck upon the chest. Their action is particularly manifested in an attempt to raise the head while lying upon the back. Still there is a position in which this muscle may become an extensor of the head, viz. when it is thrown very far backwards; and this effect is owing to the nature of the upper insertion, which is situated somewhat behind the fulcrum of the lever represented by the head.

This muscle affords one of the most remarkable examples of the co-operation or simultaneous action of several muscles, in order to give effect to the action of one. Thus, in order that the sterno-cleido-mastoid may act most advantageously upon the head, it becomes necessary that the sternum being the fixed point, should be maintained as immoveable as possible, and this can only be effected by the contraction of the recti muscles of the abdomen. These latter in their turn require a fixed point at the pelvis, and this renders necessary the contraction of the glutæi, the semi-tendinosus, the semi-membranosus, and biceps femoris on either side; and lastly, for the action of these, the legs require to be fixed by means of their extensor muscles.

This remarkable simultaneous contraction of so many muscles, necessary for the action of but one, has been extremely well illustrated by Winslow. It has many important results both in physiology and in pathology.

MUSCLES OF THE INFRA-HYOID REGION.

The sterno-hyoideus. — Scapulo- or omo-hyoideus. — Sterno-thyroideus. — Thyro-hyoideus.

The muscles of the infra-hyoid region are four in number on each side, viz. the sterno- or rather cleido-hyoid; the omo-hyoid; and the sterno-thyroid, which is continuous above with the fourth muscle, viz. the thyro-hyoid.

The Sterno-hyoideus.

Dissection. This is extremely easy, and is the same for all the muscles of this region. The only caution necessary is that the clavicular and sternal attachments of these muscles should be studied from their posterior aspect only, and that the trapezius must be removed in order to expose the scapular attachments of the omo-hyoid.

The *sterno-hyoid* (*l, figs.* 113 and 114.) is a flat, thin, ribbon-like muscle, which is sometimes double on each side. It *arises* from the inner end of the clavicle, and is *inserted* into the os-hyoides. Its inferior attachment is liable to some variations; most commonly it is connected with the back part of the inner extremity of the clavicle and with the inter-articular cartilage; sometimes with the outer side of that extremity; and sometimes with the circumference of the clavicular surface of the sternum. From this origin the fleshy fibres proceed parallel to each other, upwards and inwards, to be inserted by short tendinous fibres into the lower edge of the body of the os hyoides on the side of the median line and to the inside of the omo-hyoid, with which it is often blended. Immediately above the clavicle this muscle is often divided by an aponeurotic intersection, which is united to that of the opposite side and forms, as it were, a transverse bridle.

Relations. It is covered by the platysma, the sterno-mastoid, and the cervical fascia. It covers the deep-seated muscles, the thyroid body, the crico-thyroid and thyro-hyoid membranes, from which it is often separated by a bursa mucosa, the crico-thyroid muscle, and the superior thyroid artery. The inner edges of the two sterno-hyoid muscles are generally separated by a fibrous raphé, but they are sometimes blended together; and thus render the operation of tracheotomy more difficult. This impediment may, however, be overcome by keeping accurately in the median line.

The Scapulo- or Omo-Hyoideus

This muscle (coraco-hyoideus, *Albinus; m m, figs.* 113. and 114.) is longer and more slender than the preceding; it is a digastric reflected muscle, composed of two small fleshy bellies, united by an intermediate tendon. It *arises* from the superior border of the scapula behind the coracoid notch, over an extent varying from a few lines to an inch, and is *inserted* into the lower part of the body of the os hyoides, externally to the sterno-hyoid. From its origin, which is sometimes tendinous, it proceeds for a variable distance behind and parallel to the clavicle, and is then reflected upwards and inwards, at an obtuse angle. At the point of reflection it becomes entirely or partially tendinous; and gives origin to another fleshy bundle larger than the former, which is inserted into the os-hyoides.

The angular direction of this muscle is maintained by means of an aponeurosis, first described by Sœmmering, which extends between the inner borders of the two muscles, and is fixed to the clavicle: it is one of the layers of the cervical fascia, an important structure to be again alluded to hereafter, and of which the omo-hyoid muscles are tensors. These muscles are occasionally wanting; sometimes they are double. In one case of this kind the accessory muscle was larger than the normal one, and arose from the upper and internal angle of the scapula.

Relations. This small muscle, before reaching the sub-hyoid region, traverses two others, the supra-clavicular and the sterno-mastoid. It is covered by the trapezius, the subclavius, the clavicle, the platysma, the sterno-mastoid, and the skin; it covers the scaleni, the brachial plexus, the internal jugular vein, and the common carotid artery, and it is in contact with the outer border of the sterno-hyoid muscle.

The Sterno-thyroideus.

The *sterno-thyroid* (*n, fig.* 114.) closely corresponds with the sterno-hyoid, from which it differs only in being shorter and broader. It extends from the posterior surface of the sternum to the thyroid cartilage. It *arises* from the sternum opposite the first rib; it is often blended with its fellow, so that their origins form a line reaching the entire breadth of the sternum, and often to the edges and posterior surface of the cartilage of the first rib.

From this origin the fleshy fibres proceed directly upwards parallel to each other, and are *inserted* into the thyroid cartilage by a tendinous arch running obliquely downwards and inwards, which embraces the thyro-hyoid muscle, and is attached by its extremities to two very prominent tubercles on the external surface of the cartilage. It is sometimes continued as far as the os hyoides by a small lateral prolongation, and at other times it is continuous with the thyro-hyoid. The sterno-thyroid is interrupted by a tendinous intersection analogous to those of the rectus abdominis. It is not uncommon to find the two sterno-thyroid muscles united together by an intervening aponeurosis shaped like the letter V, opening upwards, and corresponding to the fourchette of the sternum.

Relations. It is covered by the sterno-hyoid and omo-hyoid muscles, and it covers the trachea, the lower part of the subclavian and internal jugular veins, the common carotid artery, and the arteria innominata on the right side, the thyroid body and the thyroid vessels. The middle thyroid vein runs along its inner border, an important relation in regard to the operation of tracheotomy.

The Thyro-hyoideus.

This is a small quadrilateral muscle (hyo-thyroideus, *Albinus*), which may be considered a continuation of the sterno-thyroid (*o, figs.* 113. and 114.). It *arises* from the oblique line, and the tubercles of the thyroid cartilage, where

it is embraced by the tendinous arch of the preceding muscle, passes vertically upwards, and is *inserted* into the posterior surface of the body and part of the great cornu of the os hyoides.

Relations. It is covered by the two muscles of the superficial layer, and covers the thyroid cartilage, and the thyro-hyoid membrane.

Action of the muscles of the sub-hyoid region. These muscles are the most simple, both in structure and in action: they all concur in depressing the lower jaw; but if the lower jaw is fixed they produce flexion of the head. The fixed points of all are below, viz. at the sternum on the inside, at the clavicle in the middle, and at the scapula on the outside. This arrangement not only bestows particular uses upon each, but renders the common action of all more certain. Thus, the omo-hyoid at the same time that it depresses the os hyoides, carries it backwards and towards its own side. Where the two omo-hyoid muscles act together, the os hyoides is directly depressed, and forced backwards against the vertebral column. The sterno-hyoid and the sterno-thyroid prolonged by the thyro-hyoid, draw the os hyoides directly downwards. The principal use of the thyro-hyoid is to move the os hyoides upon the thyroid cartilage, in which movements the upper part of the cartilage is carried behind the os hyoides, the curve described by which is always greater than that formed by the cartilage. The muscles of the sub-hyoid region never assume as their moveable points either their sternal, clavicular, or scapular attachments.

MUSCLES OF THE SUPRA-HYOID REGION.

The digastricus. — Stylo-hyoideus. — Mylo-hyoideus. — Genio-hyoideus. — Their action.

THE muscles of this region, taken in the order of super-imposition, are the digastric, the stylo-hyoid, the mylo-hyoid, and the genio-hyoid.

The Digastricus.

Dissection. Remove the platysma, reflect the mastoid insertion of the sterno-mastoid; detach and raise the sub-maxillary and the lower extremity of the parotid gland.

Fig. 114.

The *digastric* muscle biventer maxillæ inferioris, *Albinus, p p, figs.* 113 and 114.), so named because it consists of two fleshy bellies, united by an intermediate tendon, reaches the whole extent of the supra-hyoid region, from behind forwards. It is in some respects the type of digastric muscles. It is curved upon itself, forming the arc of a circle, with the concavity directed upwards.

It *arises* from the digastric groove in the mastoid process, and from the anterior edge of that process, in front of the sterno-mastoid; it is *inserted* into the side of the sym-

physis menti, below the sub-mental tubercles, into the whole extent of the digastric fossa. It is also attached to the os hyoides by means of an aponeurotic expansion.

Its *origin* from the mastoid process is partly fleshy, and partly tendinous, the tendon being prolonged for some distance upon the upper border of the muscle. The fusiform fleshy belly produced in this manner passes forwards, inwards, and downwards, into the interior of a sort of fibrous cone, forming the commencement of the intermediate tendon. This tendon, which is about two inches in length, follows at first the direction of the muscle, almost always perforates the stylo-hyoid muscle, and is then received into a fibrous ring attached to the os hyoides, and lined by a synovial capsule. This fibrous ring is often wanting. A broad aponeurotic expansion proceeds from the intermediate tendon and is fixed to the os hyoides. When this is united to the corresponding structure on the opposite side, they form a very strong, triangular aponeurosis, called the *supra-hyoid aponeurosis*, which occupies the interval between the two muscles, and serves as a kind of floor for the other muscles of the supra-hyoid region. After having passed through the fibrous ring, the tendon changes its direction, and is reflected at an obtuse angle upwards and forwards, to terminate in another tendinous cone. From the interior of this cone the fleshy fibres of the anterior belly take their origin. This belly is not so strong as the posterior, and is inserted by separate tendons, sometimes intersecting those of the opposite side, into the whole extent of the digastric fossa, below the sub-mental tubercles. Some fibres are often blended with those of the mylo-hyoid. It is not uncommon to see a small fasciculus arising from the os hyoides, and strengthening the anterior belly. The two anterior bellies are sometimes united by a raphé, and by a small transverse fibrous bundle.

Relations. It is covered by the platysma and sterno-mastoid, the parotid and the submaxillary glands, the latter of which it embraces by the concavity of its upper border: it covers the muscles which arise from the styloid process, the mylo-hyoid muscle, the internal jugular vein, the external carotid artery, and its labial and lingual branches, the internal carotid, and the hypo-glossal nerve, which lies parallel with and beneath the intermediate tendon of the muscle.

Its *action* is very complicated: when the posterior belly contracts alone, the os hyoides is carried backwards and upwards; the anterior belly carries it forwards and also upwards. When the two bodies of the muscle contract at the same time, these opposite effects are destroyed, and the os hyoides is carried directly upwards. In all these motions, the lower jaw must be fixed. If the os hyoides is fixed, the posterior belly becomes a depressor of the jaw, on account of the reflection of the muscle; the anterior and the posterior bellies can incline the head backwards, but this inclination of the head backwards during mastication, and when the jaws are separated, depends on the action of the posterior extensor muscles of the neck: lastly, the anterior belly of the digastric is the tensor of the supra-hyoid fascia.

The Stylo-hyoideus.

Dissection. Detach the posterior belly of the digastric. This is a small and very thin muscle (*q, figs.* 114.; *q q, figs.* 143 and 147.) like all those which are attached to the styloid process.

It *arises* from the back of the styloid process, at a short distance from the apex, and opposite the insertion of the stylo-maxillary ligament. This origin consists of a small tendon, which terminates in a fibrous cone, from the interior of which the fleshy fibres commence. These proceed downwards, forwards, and inwards, and form a bundle which is almost always perforated by the tendon of the digastric. Occasionally the fibres pass only in front of that

tendon. They are *inserted* into the body of the os hyoides, at a short distance from the median line. Sometimes the tendon of insertion is reflected upon itself, and forms the pulley for the digastric.

Relations. It is covered by the posterior belly of the digastric, and has the same relations as that muscle. It is not uncommon to find a second stylo-hyoid muscle, extending from the styloid process to the little cornu of the os hyoides. This muscle takes the place of the stylo-maxillary ligament; it was described by Santorini under the name of the *stylo-hyoideus novus*, and was noticed also by Albinus.*

The Mylo-hyoideus.

Dissection. Detach the anterior belly of the digastric at its maxillary insertion; dissect the submaxillary gland, and turn it outwards.

This muscle (*r*, *figs.* 113 and 114.) situated immediately below, *i.e.* deeper (as regards the surface) than the anterior belly of the digastric, is thin and quadrilateral. It *arises* from the whole extent of the mylo-hyoid line, from opposite the last molar to the symphysis menti, by short aponeurotic fibres. The fleshy fibres arising from these pass in different directions: the internal (or anterior), very short, proceed inwards to a median fibrous raphé, which traverses the whole supra-hyoid region; the external (or posterior) pass much less obliquely to the upper part of the body of the os hyoides. The median raphé is sometimes wanting, and the muscular fibres of the opposite sides are continuous with each other. Some of the fibres are often lost in the digastric, and are even continuous with the sterno-hyoid. The two mylo-hyoid muscles may, with great propriety, be regarded as a single muscle, divided by a tendinous intersection in the median line.

Relations. It is covered by the anterior belly of the digastric, the supra-hyoid fascia, the platysma, and the sub-maxillary gland; and it covers the genio-hyoid, the hyo-glossus, and stylo-glossus muscles, the lingual and hypo-glossal nerves, the Whartonian duct, the sublingual gland, and the buccal mucous membrane.

The Genio-hyoideus.

This muscle (*s*, *fig.* 114, 143, 147.) is situated below, *i.e.* deeper than the preceding, which must be divided very carefully in order to avoid raising the two together It is a small, round, fleshy bundle, described by anatomists as consisting of two very minute muscles, separated from each other by an extremely delicate cellular tissue. Sometimes it is impossible to separate them; at other times the two bundles are very distinct. They *arise* from the inferior sub-mental tubercle, and proceed downwards and backwards to be *inserted* into the upper part of the os hyoides.

Relations. They are covered by the mylo-hyoids, and cover the hyo-glossal muscles.

Actions of the Muscles of the Supra-hyoid Region.

These are of two kinds, relating to the depression of the lower jaw and to the elevation of thc os hyoides.

The os hyoides being fixed by the muscles of the sub-hyoid region, all the supra-hyoid muscles, with the exception of the stylo-hyoids, depress the lower jaw; and it should be observed that they are situated in the most favourable manner for this purpose; for, on the one hand, they are almost perpendicular to the lever, and, on the other, they are attached as far as possible from the fulcrum. The obliquity of their direction has also this advantage, that the lower jaw is carried backwards as well as depressed, and thus the orifice of the mouth is greatly increased in size.

* Albinus termed it *stylo-hyoideus alter*.

But the most important action of these muscles relates to the elevation of the os hyoides. This elevation is an indispensable element in the act of deglutition, and also in the protrusion of the tongue. Thus the os hyoides is carried upwards and backwards by the stylo-hyoid muscles and by the posterior belly of the digastric, upwards and forwards by the anterior belly of the digastric and by the mylo- and genio-hyoids, and directly upwards by the combined action of all these muscles. The base of the tongue, of which the os hyoides constitutes, in some degree, the framework, is associated with it in all these movements, which take place at different periods of deglutition: thus the movement upwards and forwards is effected during the period when the alimentary mass is driven from the cavity of the mouth into the pharynx, which enlarges for its reception. The direct elevation takes place when the mass is passing, and the movement upwards and backwards occurs after it has passed, so as to prevent its return into the mouth. When the lower jaw is fixed against the upper, and the os hyoides is also fixed by the sub-hyoid muscles, the muscles of the supra-hyoid region assist in flexing the head. Lastly, the os hyoides is elevated during the production of acute, and depressed during that of grave, vocal tones.

MUSCLES OF THE CRANIAL REGION.

Occipito-frontalis. — Auricular muscles.

THE muscles of the cranial region are the occipito-frontalis and the auricular muscles.

The Occipito-frontalis.

Dissection. Shave the head, and make a horizontal incision above the superciliary arch; make a second incision in a vertical direction from before backwards, and reaching from the former to the superior semicircular line of the occipital bone; be very careful not to dissect away the epicranial aponeurosis, nor the fibres of the muscle; commence the dissection at the fleshy fibres, which adhere less intimately to the skin than the aponeurosis.

The *occipito-frontalis* (epicranius, *Albinus, a' a', fig.* 113.) is sometimes regarded as one muscle with two bellies; sometimes as a combination of two separate muscles, the *occipital* and the *frontal*. It covers the roof of the skull. We shall describe the occipital and frontal portions only; the aponeurosis will be elsewhere noticed. (Vide APONEUROLOGY.)

1. The *occipital portion*, or *occipital muscle*, covers a great part of the occipital bone, and is situated over the superior occipital protuberance. It is thin and quadrilateral. It *arises* from the two external thirds of the superior semicircular line, and from the neighbouring part of the mastoid process of the temporal bone, and is *inserted* into the posterior border of the cranial aponeurosis, of which it may be regarded as the tensor. The occipital attachment is composed of tendinous fibres; the fleshy fibres proceeding from which pass upwards in a parallel direction, and, after a short course, terminate in the aponeurosis.

2. The *frontal portion*, or *frontal muscle*, is placed at the front of the cranium; it is thin, and irregularly quadrilateral like the preceding. It is attached above to the cranial aponeurosis, and terminates below in the following manner:— 1. The internal or median fibres are prolonged into a fleshy band, which constitutes the pyramidalis nasi; 2. the fibres next on the outside are continuous with those of another muscle, viz. the levator labii superioris alæque nasi — to the outside of these fibres, the muscle is attached to the internal orbital process; 3. the greater number of the fibres are blended with those of the orbicularis palpebrarum. The upper border of the muscle, which is attached to the aponeurosis, forms a semicircular line, that, in many individuals, causes a projection under the skin.

Relations. The occipito-frontalis covers the roof of the skull; hence the name of epicranius (*Albinus*). It rests upon the pericranium (the periosteum

of the cranial bones), being separated from it by a quantity of moist cellular tissue, which admits of a considerable degree of mobility of the integuments, and is so elastic that it returns to its original situation after being displaced by any movements of the hairy scalp. The superficial surface of this muscle is covered by the skin, and is united to it by a very dense, almost fibrous cellular tissue, in which are ramified the numerous vessels and nerves of the cranial integuments.

Action. The occipital portion is a tensor of the epicranial aponeurosis, which when stretched affords a fixed point for the frontal portion. This latter raises the upper half of the orbicularis palpebrarum, elevates the eyebrows and the skin over the root of the nose, and has a great effect in the expression of emotions of delight. This muscle produces the transverse wrinkles on the forehead, which give to the countenance of individuals who are habitually gay, a peculiar expression, that is often imitated by painters. These transverse wrinkles do not extend over the triangular interval, which separates the two fleshy bellies of the muscle in the centre of the forehead.

The occipito-frontalis must be regarded as an elevator of the upper eyelids; it is blended with the orbicularis palpebrarum in the same manner as the labial muscles with the orbicularis oris. In this respect the occipito-frontalis is assisted by the levator palpebræ superioris, and antagonised by the corrugator supercilii and orbicularis palpebrarum. Can this muscle erect the hairs on the head? It is certain that it can move the entire hairy scalp, for many individuals are able to do this at will; but it appears to me that the expression, *the hairs stand on end*, as regards man, is merely figurative, and is derived from what occurs in the lower animals, in which this erection of the hair is very manifest. Perhaps, however, the skin itself may produce this effect by the same mechanism as that which gives rise to *goose skin*.

The Auricular Muscles.

Dissection. Be very careful in dissecting the superior and anterior auricular muscles, which are extremely thin, and consist only of a few colourless fibres. To render them as tense and prominent as possible, it is necessary to draw the ear away from the muscle to be examined.

All these muscles are rudimentary in man, in whom the external ear is almost immoveable. They may all be considered as dilators of the auditory meatus, to which there is no constrictor or sphincter in the human subject: certain animals, however, possessing a very delicate sense of hearing, have constrictor muscles, which draw together and move the different pieces forming the cartilaginous portion of this canal.

The auricular muscles are three in number: a superior, an anterior, and a posterior.

The Auricularis Superior.

This muscle, which is extremely thin and of a triangular form (*b'*, *fig.* 113.), occupies the temporal fossa. It *arises* from the external border of the epicranial aponeurosis, of which it seems to be a dependence; from this origin its fibres converge, and are *inserted* into the upper part of the concha. It is covered by the skin, and lies upon the temporal fascia.

Action. To raise the ear (attollens auriculam, *Albinus*).

The Auricularis Anterior.

This muscle (*c'*, *fig.* 113.) is still thinner and less marked than the preceding, with which it is continuous. It is also triangular, and *arises* from the outer edge of the occipito-frontalis, and the cellular tissue covering the zygomatic region; the fibres converge from their origin, and are *inserted* into the front of the helix. It is covered by the skin, and lies upon the temporal fascia, from which it is separated by the temporal artery and vein.

Action. To draw the auricle forwards and upwards (anterior auriculæ, *Albinus*).

The Auricularis Posterior.

This muscle (*d'*, *fig.* 113.) is much more decidedly marked than the preceding, and is composed of two or three distinct fleshy fasciculi (tres retrahentes auriculam, *Albinus*), which extend from the base of the mastoid process, and sometimes also from the occipital bone, to the lower part of the concha.

Action. To draw the auricle backwards.

MUSCLES OF THE FACE.

All the muscles of the face are arranged in groups around its several openings, and may be classed either as dilators or constrictors. The nostrils alone have no constrictors.

The eyelids must be opened and closed entire, without the production of any folds; the nostrils must remain constantly open, for the skin around these orifices has within it a corresponding lamina of cartilage, which gives it the necessary tension, strength, and elasticity, and into which the muscles are inserted. There is no such arrangement at the orifice of the mouth, the muscles being there inserted into other muscles.

From the three openings around which the muscles of the face are grouped, these may be arranged into three distinct regions, viz. the palpebral, the nasal, and the buccal.

Muscles of the Palpebral Region.

Orbicularis palpebrarum. — Superciliaris. — Levator palpebræ superioris.

The muscles of the eyelids are divided into constrictors and dilators. There is one constrictor, viz. the orbicularis palpebrarum, to which the corrugator supercilii is an accessory; there is also one elevator, viz. the levator palpebræ superioris.

The Orbicularis Palpebrarum.

Dissection. Make an elliptical incision through the skin round the base of the orbit; dissect successively the upper and lower half of the muscle, proceeding from the adherent towards the free border of each eyelid. It is of more importance here, than in any other situation, to dissect the skin parallel to the fleshy fibres. When the external surface of the muscle has been studied, detach it carefully from the subjacent parts, and reflect it inwards.

The *orbicularis palpebrarum* (*e'*, *fig.* 113.) forms an elliptical zone of variable size round the eyelids, and also an extremely thin layer upon them. It is a sphincter, and, like all muscles of this kind, is composed of circular fibres; but, as a special exception, it is also provided with a remarkable tendon of origin, named the *straight tendon of the orbicularis*: this is about two lines in length, and half a line in breadth, arises from the ascending process of the superior maxilla, anteriorly to the lachrymal groove, and passes in front of the lachrymal sac, where it divides into two unequal parts, an upper and smaller, and a lower more capacious; sometimes it corresponds entirely to the upper part of the sac. At first it is flattened from before backwards, but is then twisted upon itself, so as to present one surface upwards and another downwards. Opposite the inner angle of the eyelids, this tendon, which is also called the *palpebral ligament*, becomes bifurcated, and each division is attached to the inner end of the corresponding tarsal cartilage; from the posterior surface of the tendon a very strong aponeurotic lamina is given off, and forms the outer wall of the lachrymal sac — this is the *reflected tendon of the orbicularis palpebrarum.* Fleshy fibres proceed from the anterior and posterior surfaces, and from the borders of the straight tendon, and also from the anterior border of the reflccted tendon; but the greater number arise by well-marked tendinous prolongations from the external orbital process of the frontal bone, from the ascending process of the

superior maxilla, and from the internal and lower third of the base of the orbit. From these origins the fleshy fibres pass outwards, dividing into two halves, an upper, which describes concentric curves with the concavity directed downwards, and a lower also describing concentric curves, but with the concavity directed upwards (duo palpebrarum musculi, *Vesalius*). Each of these halves is subdivided into two sets of fibres, an external set surrounding the base of the orbit, and an internal or palpebral belonging to each eyelid: hence the distinction drawn by Riolanus between the *orbicularis* and the *ciliaris* or *palpebralis* muscles. The external fibres (forming the orbicular portion) describe a complete ellipse. I have never met with the fibrous intersection at the outer part of the eye, mentioned by some anatomists. The palpebral or ciliary fibres, forming the proper palpebral portion, arise from the bifurcation of the tendon, and describe concentric arcs, which are united on the outside at an acute angle to a cellular raphé.

Relations. The orbicular portion is closely united to the skin by means of a fibrous and adipose tissue, which is very compact over the upper, and loose over the lower, portion of the muscle; it is connected with the skin of the eyelids by a serous cellular tissue, remarkably susceptible of infiltration. It covers the lachrymal sac, the corrugator supercilii muscle, the orbital arch, the maxillary bone, the temporal muscle, and the superior attachments of the zygomaticus major, of the levator labii superioris alæque nasi, and of the levator labii superioris.

It is separated from the conjunctiva by a fibrous membrane and the tarsal cartilages. Its circumference is blended with the pyramidalis nasi on the inside, with the occipito-frontalis and corrugator above, but is free below; occasionally it gives off a few fibres from its outer border, some of which form the zygomaticus minor, and others of a paler colour terminate in the skin.

Actions. The orbicularis acts in the same manner as all other sphincters, that is to say, the circular fibres, of which it is composed, contract towards the centre; but as the fleshy fibres have their fixed point at the straight tendon, and still more at the internal insertions, it follows that during the contraction of this muscle it is thrown in some measure inwards, and by it the integuments of the forehead, the temple, and the cheek, are drawn towards the inner angle of the eye. The intimate adhesion between the skin and the upper half of the muscle explains why, during its contraction, that part is rendered more apparent beneath the skin than the lower. The palpebral portion contracts independently of the orbicular, a fact that confirms the distinction made by Riolanus. Nor is this all; the contraction of this palpebral portion, or *palpebralis muscle* properly so called, is habitually involuntary, whilst the contraction of the orbicular portion is subject to the will. The palpebral fibres are pale, and resemble the muscular fibres of the alimentary organs *; the orbicular fibres are red, like those of the muscles of animal life. When the palpebral fibres contract, they do not produce the occlusion of the eye, by a concentric approximation of the fibres, but by bringing together the free edges of the eyelids, the only method permitted by the tarsal cartilages. The curve described by the muscular fibres of the lower being smaller than that formed by those of the upper eyelid, it follows that the closing of the eyes depends principally upon the latter.

The Superciliaris.

Dissection. Make a vertical incision in the median line between the frontal muscles; turn back carefully the frontal and the orbicularis muscles from within outwards.

The *superciliaris* (corrugator supercilii, *Albinus*, *a'*, *fig.* 114.), is a narrow and tolerably thick fasciculus, generally of a deeper red than the orbicularis, and situated along the superciliary arch, with the direction of which it corre-

* See note *, p. 309.

sponds. It *arises* by one, often by two or three portions from the internal portion of this arch; proceeds upwards and outwards, describing a slight curve, having its concavity downwards, and is blended with the orbicularis palpebrarum at about the middle of the arch of the orbit. From this arrangement Albinus described it as a root of the orbicularis. According to some authors it terminates in the skin of the eyebrow (cutaneo-surcilier, *Dumas*); but I have always found it attached to the deep layer of the orbicularis muscle.

Relations. It is covered by the pyramidalis nasi, the orbicularis palpebrarum, and the occipito-frontalis, and it covers the os frontis, the supra-orbital and frontal arteries, and the frontal branch of the ophthalmic nerve.

Action. This muscle corrugates the eyebrow, and draws it downwards and inwards. It is, therefore, regarded as the principal agent in the expression of grief. The repeated contraction of these muscles in irascible individuals gives a character of severity to the countenance, from the constant approximation of the eyebrows, and the permanence of the vertical wrinkles formed between them.

The Levator Palpebræ Superioris.

Dissection. Remove the roof of the orbit by two cuts with a saw, meeting at an acute angle opposite the foramen opticum; detach the bone with care, so as to leave the periosteum untouched; cut the periosteum from before backwards, and separate the frontal nerve which passes above and parallel to the muscle, which may then be separated carefully from the superior rectus muscle of the eye.

The *levator palpebræ superioris* (see description of the eyelids) is an elongated, flat, triangular, and very thin muscle, placed in the orbital cavity, directed horizontally from behind forwards, and curved at its anterior extremity, so as to form a concavity directed downwards. It *arises* from the inferior surface of the lesser wing of the sphenoid, immediately above the optic foramen, and from the sheath of the optic nerve, and is *inserted* into the upper border of the tarsal cartilage. Its sphenoidal origin consists of a small tendon, and its attachment to the sheath of the optic nerve is a fibrous ring common to all the muscles of the eye. From these points the fleshy fibres proceed forwards, forming a broad thin bundle, increasing in width and diminishing in thickness towards its tarsal insertion, which is effected by means of a broad aponeurosis.

Relations. Covered by the periosteum of the orbit, from which it is separated by the frontal branch of the ophthalmic nerve, covered also by some adipose tissue and by the fibrous membrane of the upper eyelid, it covers the superior rectus of the eye and the conjunctiva.

Action. It raises the upper eyelid. Its reflection over the globe of the eye explains that peculiar motion of the eyelid by which its upper edge is buried below the orbital arch. The relaxation of this muscle suffices for the depression of the upper eyelid in passive closure of the eyes, while the active occlusion depends on the contraction of the orbicularis.

There is no analogous muscle for the lower eyelid, which scarcely concurs either in opening or shutting the eyes.

NASAL REGION.

The pyramidalis nasi. — Levator labii superioris alæque nasi. — Transversalis, or triangularis, nasi. — Depressor alæ nasi. — Naso-labialis.

The muscles of this region are the pyramidalis nasi, the levator labii superioris alæque nasi, the transversalis or triangularis nasi, the depressor alæ nasi, or myrtiformis, and the naso-labialis of Albinus.

The Pyramidalis Nasi.

Dissection. Trace down upon the dorsum of the nose the internal fibres of the occipito-frontalis, directing the scalpel parallel to these fibres, which have a vertical course.

The pyramidalis nasi (*f*, *fig.* 113.) is a prolongation of the internal fibres of the occipito-frontalis, of which it may be regarded as a prolongation (frontalis pars per dorsum nasi ducta, *Eustachius*). It lies upon the bridge of the nose on each side of the median line. It is separated from the muscle of the opposite side by a thin layer of cellular tissue. It is narrower at its origin than at its termination, which takes place in the aponeurosis of the transverse muscle of the nose.

Relations. It is covered by the skin, to which it closely adheres, especially below, and it covers the nasal bones and lateral cartilages.

Action. This small muscle has been regarded as an elevator of the ala, and consequently a dilator of the nose; but I believe it rather acts in depressing the inner angle of the eyebrow, and the skin between the eyebrows. In this respect it has considerable influence upon the expression of the countenance.

The Levator Labii Superioris Alæque Nasi.

Dissection. Make a vertical or somewhat oblique incision from the ascending process of the superior maxilla to the upper lip. Reflect outwards the inner and lower part of the orbicularis muscle.

This muscle (*g'*, *fig.* 113.) is thin, triangular, and divided into two portions below. It extends from the ascending process of the superior maxilla to the ala of the nose and the upper lip. It *arises* by a narrow extremity from the internal orbital process of the frontal bone, immediately below the tendon of the orbicularis palpebrarum, passes obliquely downwards and outwards, becomes much broader, and is *inserted* partly into the cartilage of the ala of the nose, or rather into the very dense skin which covers it, and partly into the orbicularis oris, or rather into the skin of the upper lip. The cutaneous portion of this muscle is distinguished by its paleness, compared with the red colour of the rest.

Relations. It is covered by the skin, and a small portion of the orbicularis palpebrarum; and it covers the ascending process of the superior maxilla, and the transverse muscle of the nose.

Action. It elevates both the ala of the nose and the upper lip. I consider it the most important of all the muscles of the nose, because the elevation of the alæ dilates the nostrils, and thus aids most essentially in cases of impeded respiration. It is a respiratory muscle of the face, and has also great influence over the countenance, producing the expression of contempt. Its action upon the upper lip is of much less importance than that upon the nose.

The Transversalis, or Triangularis, Nasi.

Dissection. Remove with great care the skin covering the ala of the nose, and then follow this muscle below the inner edge of the common elevator; or, what is better, remove all the soft parts covering the ala of the nose, and dissect the muscle from its deep surface.

The *transversalis nasi* (compressor narium, *h'*, *figs.* 113, 114.), which I regard as a dependence of the muscle next to be described, is a small and very thin triangular muscle, stretching from the inner part of the canine fossa to the bridge of the nose. It *arises* by a narrow extremity from the canine fossa, passes forwards, enlarging as it proceeds along the ala of the nose, and terminates by a very thin aponeurosis, which is blended in the median line with that of the opposite side, and with the pyramidalis. It is covered by the skin, to which it closely adheres, and by the common elevator; and it covers the cartilage of the ala, and a small part of the superior lateral cartilage of the nose.

Action. The action of this small muscle is not yet well determined. Some have agreed with Riolanus in considering it a dilator (qui alam naris dilatat

sine elevatione nasi, *Riolanus*); others think with Spigelius and Albinus that it is a constrictor of the nose (primi paris constringentium alas, *Spigelius*; compressor naris, *Albinus*). It is probable that its action *varies* according to the shape of the ala: if this be concave outwards, it is a dilator; if convex outwards, it is a constrictor. Its action is very slight.

The Depressor Alæ Nasi, or Myrtiformis.

Dissection. Evert the upper lip, and remove the mucous membrane on each side of the frænum. The two myrtiformes may then be separated by a vertical incision in the median line. It will be apparent that the myrtiformis and transversalis form only one muscle, which arises from the alveolar border near the lateral incisor, the canine and the anterior bicuspid teeth, and is distributed to the orbicularis oris, the alæ, and the septum of the nose.

This muscle (*i'*, *fig.* 114.) is short and radiated, and *arises* by a narrow extremity from the incisive or myrtiform fossa of the superior maxilla, opposite the canine and two incisor teeth (incisif moyen, *Winslow*). Its fibres diverge upwards and outwards, and are *inserted* thus: the lower or descending, behind and in the substance of the orbicularis oris, and the upper or ascending, into the ala and septum of the nose. Its upper border is not distinct from the lower border of the transversalis. Chaussier, on account of its termination in the upper lip, regarded it as one of the origins of the orbicularis oris.

Relations. It is covered by the buccal mucous membrane, by the orbicularis oris and the common elevator, and it lies upon the maxillary bone. It is continuous, without any line of demarcation, with the transversalis nasi. The inner border of the muscle of one side is separated from that of the other by an interval, corresponding to the frænum of the upper lip.

Action. It depresses the ala of the nose, and has also been considered a depressor of the upper lip (depressor labii superioris*, *Cowper*). I regard it rather as an elevator of that lip.

The Naso-labialis of Albinus.

This consists of a fasciculus which it is difficult to demonstrate in many subjects. It *arises* from the anterior extremity of the septum of the nose, passes horizontally backwards, is then reflected downwards, and terminates like the preceding in the orbicularis, of which it may be considered a root.

MUSCLES OF THE LABIAL REGION.

The orbicularis oris. — Buccinator. — Levator labii superioris. — Caninus. — Zygomatici, major et minor. — Triangularis. — Quadratus menti. — Levator labii superioris. — Movements of the lips and those of the face.

No region has so many muscles as the orifice of the mouth: seventeen, nineteen, and often twenty-one muscles are grouped round it, viz. the orbicularis oris, the common elevators of the alæ and lip already described, the proper elevators of the lip, the great zygomatics, the canine, the buccinators, the triangulares, the quadrati or the levatores menti, and often two muscles on each side, viz. the *risorius* of Santorini, and the *small zygomatic*.

The Orbicularis Oris.

Dissection. Make an elliptical incision round the opening of the mouth, and dissect back the skin with great care, the mouth being previously distended by the introduction of tow between the lips and alveolar borders.

The *orbicularis oris* (*l' l'*, *figs.* 113 and 114.), is the sphincter of the orifice of the mouth; it is essentially the constituent muscle of the lips, occupying the entire space between the free edge of the upper lip and the nose, and the free edge of the lower lip and the transverse furrow above the chin.

We shall consider, with Winslow, the orbicularis to be composed of two

* Depressor labii superioris alæque nasi of other writers.

halves, each constituted by a demi-zone, of semi-elliptical concentric fibres, terminating on either side at the commissures of the lips. These fibres, which are all fleshy, do not become continuous opposite the commissures of the lips; but only intersect each other, those of the upper half being continuous with the lower fibres of the buccinator, and those of the lower half with the upper fibres of the same muscle.

The thickness of the two halves varies in different individuals, particularly around the free borders of the lips, where the fasciculi of the muscle are somewhat everted. In the negro this is very remarkable. The thickness of the lips depending upon this circumstance must be distinguished from that which is the effect of a scrofulous habit.

Relations. These muscles are covered by the skin, to which they adhere intimately, and hence the facility of bringing together the entire depth of the surface of wounds in the lips, by retentive applications to the skin only. They cover the mucous membrane, but are separated from it by the labial glands, the coronary vessels, and a great number of nervous filaments. Their outer circumference receives all the extrinsic muscles of the lips, which terminate in these as in a common centre. Their inner circumference circumscribes the opening of the mouth. The differences in the dimensions of this opening occasion the varieties observed in the size of the mouth, but the capacity of the buccal cavity is in no way influenced by these variations.

Actions. These are exceedingly various, and may be studied as connected with the closing of the mouth, with the prehension of aliments by suction, with the playing upon wind instruments, and with the expression of the countenance. I shall here only notice the shutting of the mouth.

This may be accomplished simply by the approximation of the jaws, which is followed by a corresponding motion of the lips. In active occlusion, or that dependent on the orbicularis, two things may happen—either the lips may be closely drawn against the teeth, and their free edges applied to each other, or they may be pushed forwards and puckered; in the latter case the buccal opening, which is usually represented by a transverse line, resembles a circular or rather a lozenge-shaped orifice.

The Buccinator.

Dissection. Distend the cheeks by stuffing the mouth with tow; make a transverse incision through the skin from the commissure of the lips to the masseter muscle, and dissect back the flaps: in order to gain a good view of the posterior border of the muscle, turn downwards the zygomatic arch and the masseter, and then divide with the saw the inferior maxilla in front of the ramus.

The *buccinator* (*fig.* 113., and *b*, *figs.* 114. and 147.) is the proper muscle of the cheek; it is broad, thin, and irregularly quadrilateral. It is attached *above* to the external surface of the superior alveolar arch, along the space between the first great molar and the tuberosity of the maxilla; *below*, to the external surface of the inferior alveolar arch, or rather to that part of the external oblique line of the lower jaw which corresponds with the last two great molars; and *behind*, to an aponeurosis existing between this muscle and the superior constrictor of the pharynx (see *fig.* 147). This aponeurosis, to which the name of buccinato-pharyngeal has been given (*pterygo-maxillary ligament*), extends from the apex of the internal pterygoid process to the posterior extremity of the internal oblique line of the lower jaw. From these different origins the fleshy fibres proceed forwards, the upper somewhat obliquely downwards, the lower obliquely upwards, and the middle fibres horizontally. In consequence of this arrangement the fibres intersect each other opposite the commissure of the lips; from which points the lower fibres of the muscle proceed to terminate in the upper half of the orbicularis, while the upper fibres end in the lower half of the same muscle.

Relations. It is situated deeply behind, where it is covered by the ramus of the lower jaw, the masseter, and a small part of the temporal muscle; from all these parts, however, it is separated by a considerable quantity of adipose tissue, and by a mass of fat which exists even in the most emaciated individuals. More anteriorly it is covered by the zygomaticus major and the zygomaticus minor, and the risorius of Santorini, where the two latter exist; and at the commissure it is covered by the canine muscle (*levator anguli oris*) and the triangularis. The Stenonian duct runs along this muscle before passing through it; the buccal nerves and the branches of the transverse facial artery lie parallel to its fibres; the external maxillary (*i. e.* the facial) artery and vein pass perpendicularly across it near the commissure. A peculiar aponeurosis, called the *buccal* fascia, is closely united to it, and intervenes between it and all these parts. It covers the mucous membrane of the cheek, from which it is separated by a dense layer of the buccal mucous glands.

Action. It is the most direct antagonist of the orbicularis. When the cheeks are not distended, its contraction elongates the opening of the mouth transversely, and consequently renders the lips tense, and produces a vertical fold upon the skin of the cheek. This fold becomes permanent in the aged, and constitutes one of their most prominent wrinkles.

When the cheeks are distended by air, or any other substance, the buccinator becomes curved instead of flat, and acquires all the properties of the former class of muscles. Thus the first effect of its contraction is, that its fibres become straight, or have a tendency to become so; gaseous, liquid, or solid bodies, are then expelled from the mouth — rapidly, if the orbicularis offer no obstacle, and gradually, should that muscle contract. The buccinator therefore fulfils an important office in performances upon wind instruments; and hence its name (*buccinare*, to sound the trumpet). In mastication it is of no less importance, since it pushes the food between the teeth, and expels it from the sort of groove existing between the cheeks and the alveolar arches.

The Levator Labii Superioris.

Dissection. Reflect the lower half of the orbicularis palpebrarum upwards, and dissect with care the lower extremity of the muscle about to be described, which adheres closely to the skin. It can be best studied from the inner surface.

This muscle (*c'*, *fig.* 114.) is thin and quadrilateral. It is situated upon the same plane as the common elevator, of which it appears to be a continuation, and extends from the base of the orbit to the skin of the upper lip.

It *arises* from the inner half of the lower edge of the base of the orbit, on the outer side of the common elevator: from this origin, which is sometimes bifid, the fibres converge downwards and inwards, and are *inserted* successively into the skin, probably into the bulbs of the hairs, as in animals which have moustaches; so that this muscle would deserve the name of *moustachie*, which is given by some anatomists to the naso-labial of Albinus.

Relations. Its two upper thirds are deeply seated; its lower third adheres closely to the skin. It is worthy of notice that almost all the muscles of the face are deeply seated at one of their extremities, and terminate by the other in the skin. It is covered by the orbicularis palpebrarum and the skin, and it covers the infra-orbital vessels and nerves, as they escape from the infra-orbital canal. It is also in relation with the canine muscle, from which it is separated by a quantity of adipose tissue, with the transversalis nasi, and with the orbicularis oris, being interposed between the latter muscle and the skin.

Action. It raises the upper lip, and draws it a little outwards.

The Caninus.

Dissection. Merely reflect the levator labii superioris.

The canine muscle (levator anguli oris, *Albinus*, *d*, *fig.* 114.), so named from

its origin, arises from the canine fossa by a broad attachment, from which it proceeds downwards and a little outwards, diminishing in size, and becoming gradually more superficial, to the commissure of the lips, where it terminates by uniting with the zygomaticus major, and becoming continuous with the triangularis oris. We often find some accessory fibres arising from this muscle, and attached to the skin opposite the commissure.

Relations. Above, it is concealed by the levator labii superioris and the infra-orbitary vessels and nerves; below, it is quite superficial, being only covered by the skin. It covers the superior maxilla, the buccinator, and the buccal mucous membrane.

Action. It raises the angle of the mouth, and from its oblique position draws it inwards.

The Zygomatici Major et Minor.

Dissection. Make an oblique incision from the malar bone to the commissure of the lip, and remove carefully from the great zygomatic the fatty tissue which surrounds it.

The Zygomaticus Major.

This muscle (*m'*, *fig.* 113.) is a cylindrical fleshy fasciculus extending from the malar bone to the commissure of the lip. It *arises* by tendinous fibres from the entire length of a horizontal furrow situated above the lower edge of the malar bone. The fleshy fibres approach each other so as to form a fasciculus, which passes obliquely downwards and inwards towards the commissure, where it is closely united to the canine muscle, and, like it, is continuous with the triangularis or depressor anguli oris.

Relations. It is covered by the skin from which it is separated above by the orbicularis palpebrarum, and below by a large quantity of adipose tissue; it covers the malar bone, the masseter and buccinator muscles, a great collection of fat, and the labial vein.

Action. It draws the angle of the mouth upwards and outwards; by carrying the commissure upwards it assists the canine muscle, but in drawing it outwards it antagonises the same. When the zygomatic and canine contract together, the commissure is drawn directly upwards.

The Zygomaticus Minor.

This small muscle (*n'*, *fig.* 113.), which is often wanting, may be regarded as a dependence of the proper elevator of the upper lip. It arises from the malar bone above the great zygomatic, passes downwards and inwards to the outer border of the levator labii superioris, with which it is blended. It is not uncommon to find this muscle enlarged by fasciculi given off from the outer and lower circumference of the orbicularis muscle of the eyelids. It is covered by the skin and the orbicularis palpebrarum; and it covers the canine muscle and the labial vein.

Action. It assists the common elevator in raising the upper lip and drawing it somewhat outwards.

The Triangularis, or Depressor Anguli Oris.

Dissection. Make a vertical incision of the skin, from the commissure of the lips to the base of the jaw; then follow the course of the muscular fibres as they are successively exposed.

This muscle (*o'*, *fig.* 113.) is of a triangular shape, as its name implies, and belongs to the inferior maxillary region. It *arises* by a broad base within, from the lower border of the inferior maxilla on the side of the median line, and sometimes from the median line itself; and without, from the external

oblique line: from these points the fibres pass in different directions, the external almost vertically upwards, the internal obliquely upwards and outwards (the obliquity increasing as we proceed inwards), and describing a curve with the concavity looking inwards. All these fibres are concentrated into a narrow and thick fasciculus, which terminates at the commissure on a plane anterior to the fibres of the buccinator and the orbicularis oris, being evidently continuous with the canine and the great zygomatic.

Relations. It is covered by the skin, beneath which it is clearly discernible, and it covers the quadratus menti, the platysma, and the buccinator. Some colourless fibres which intersect those of the quadratus at a right angle, and moreover follow the same direction as those of the triangularis, may be regarded as a dependence of that muscle, to the inside of which they are situated. They terminate in the skin, like those of the quadratus.

Action. It depresses the angle of the mouth, thus antagonising the canine muscle and the great zygomatic, with which it is continuous. The continuity of these muscles is so manifest, that they may be regarded as constituting a single muscle, broad and triangular below—bifid above, to form the canine and zygomatic—and narrow in the middle, where it corresponds to the commissure. The internal fibres of the triangularis, from their oblique direction, are directly opposed to those of the canine muscle; but its external fibres have not a similar relation to those of the zygomaticus major.

The Quadratus Menti, or Depressor Labii Inferioris.

Dissection. Dissect back the skin covering this muscle, cutting obliquely downwards and outwards.

The *quadratus menti* (*p'*, *fig.* 113.; *q'*, *fig.* 114.), situated to the inside of the preceding, is of a square or rather lozenge shape. It *arises* from the external oblique line of the lower jaw, and is in a great measure continuous with the platysma, the fibres of which pass behind and sometimes through the triangularis. From this origin it proceeds obliquely upwards and inwards, therefore in an opposite direction to the triangularis, and is *inserted* into the skin of the lower lip, on a plane anterior to the corresponding half of the orbicularis oris. It is closely united to the skin, and covers the lower jaw, the mental nerve and vessels, the lower half of the orbicularis oris, and the muscle next to be described, with which it is intimately connected. It is separated from the muscle of the opposite side by the prominence of the chin below, but is blended with it above.

Action. It depresses the lower lip: from the obliquity of this muscle, it also draws outwards and downwards each half of the lower lip, which is therefore stretched transversely.

The Levator Labii Inferioris.

Dissection. Evert the lower lip; divide the mucous membrane at its reflection upon the lip from the lower jaw, so as to expose the origin of the muscle. In order to show its cutaneous insertion, carefully dissect off the skin covering the chin. As the muscles of each side are blended in the median line, it is necessary to make a vertical incision from before backwards, opposite the symphysis, in order to separate them.

This muscle (levator menti, *Alb.*, *r'*, *fig.* 114.) is a small conoid fasciculus, which forms in a great measure the prominence of the chin. It *arises* from the facette on the side of the symphysis menti, opposite the incisor teeth, whence the name incisif inférieur, *Winslow*, which is also given to this muscle. From this point the fibres expand like a tuft, downwards and forwards, to be *inserted* into the skin. It is red and fasciculated at its origin above, but pale, intermixed with fat, and not fasciculated below, where it is blended on the inside with the opposite muscle, and on the outside with the quadratus menti.

Its upper fibres form a concavity above, which partially embraces the great circumference of the lower half of the orbicularis oris.

Action. It raises and wrinkles the skin of the chin, and consequently raises the lower lip and projects it forwards. It appears somewhat singular, at first, that an elevator of the lip should be situated below it.

General Considerations regarding the Movements of the Lips, and those of the Face in general.

If we take a general view of the muscles of the face, we shall observe, 1. that no region is provided with so great a number of muscles; 2. that all these muscles are attached to a bone by one extremity, whilst the other is implanted into the skin, or into other muscles; 3. that the cutaneous portion of these muscles is colourless and non-fasciculated, presenting all the characteristics of involuntary muscles *; 4. that those portions which are attached either to the bone or to other muscles have, on the contrary, all the characters of the voluntary muscles.

All these muscles are arranged around the several openings of the face, and consequently they are either constrictors or dilators; the orifice of the mouth, however, is peculiar † in having the greater number of the muscles of the face specially intended for it. Indeed the orbicularis oris, or sphincter of the mouth, is antagonised by the buccinators or transverse dilators; by the proper elevators of the upper lip, and the common elevators of that and the alæ of the nose; by the depressors of the lower lip, or quadrati; by the elevators of the angle of the mouth, viz. the canine muscles, the zygomatici majores, and, where they exist, the zygomatici minores, and the two risorii of Santorini; and, lastly, by the depressors of the commissure, or triangulares oris.

The lips fulfil a great number of uses, all requiring a considerable degree of mobility. They serve for the prehension of aliments, for suction, and for the articulation of sounds, whence the name *labial* given to consonants, specially produced by the action of the lips, as *b, p, m*: they modify the state of the expired air, so as to produce in it vibrations of a peculiar character, constituting the act of whistling; and in this respect they illustrate the mechanism of the glottis: they assist in mastication by retaining the food, and constantly forcing it between the teeth: they are also employed, during performances upon wind instruments, in regulating the volume of the column of air which strikes upon the body to be thrown into vibrations. The mechanism of their action varies according to the kind of instrument: sometimes, for example, they assist in graduating the rapidity of the column of air, by influencing the orifice through which it issues, as occurs in playing upon the flute; and sometimes they represent vibrating cords, situated at the mouth of an instrument, and determining the different tones by their various degrees of tension. In this case, the lips themselves become the vibrating bodies, and propagate their oscillations to other bodies with which they are in contact, in-

* This similarity is limited, however, to the colour and general aspect of the two kinds of muscles; for even the palest muscular fasciculi of the face are found to consist of *striated* fibres, precisely similar to those of the other voluntary muscles; but the fasciculi into which they are collected are neither so evident nor so large.

† Man greatly exceeds all animals in the number of muscles attached to his lips. The ape, which is remarkable for the great mobility of its physiognomy, has, properly speaking, only one muscle for the entire face, which is a dependence of the platysma (or cutaneous muscle); therefore the play of its countenance is confined to a grimace, which is always the same, only differing in intensity, and which does not permit it to express different and even opposite passions, such as are often depicted upon the human countenance.*

* [The platysma myoides in monkeys is certainly extended, as a single muscle, over the entire cheek, and forms a muscular layer covering the lateral pouches appended to the mouth in some of that tribe of animals. In addition to this, however, monkeys have precisely the same number of muscles attached to their lips as in the human subject: they possess, indeed, all the facial muscles found in man; and, like him, they appear to be capable of expressing by changes in their features a variety of internal emotions.]

dependently of the effect produced in the instrument from the passage of a column of air. Examples of this are observed in playing on the horn, trumpet, &c.

If we examine the muscles of the face in connection with their influence in producing emotional expressions, we shall find that they are often almost completely removed from the influence of the will, as, for example, where those emotions are not simulated; but that sometimes, on the contrary, their contraction is altogether voluntary, as in those individuals, who either by profession or habit are accustomed to imitate feelings which they do not really experience. Nevertheless, it should be remarked, that although the outward expression of every passion may be produced at will upon the face, yet there is always a great difference between the natural emotion and the fictitious representation.

On the whole, the general expressions of the countenance may be regarded as varieties of two great types, viz. those of the cheerful and those of the melancholy emotions. The cheerful emotions are expressed by the expansion of the features, *i. e.* their retraction from the median line, a movement that is due to the occipito-frontalis, the levatores palpebrarum, and especially to the great zygomatic muscles. The melancholy passions, on the contrary, are expressed by the approach or concentration of the features towards the median line, which is chiefly effected on either side of the face by the corrugator supercilii, the depressor anguli oris, the common and proper elevators of the upper lip, the levator labii inferioris, and the quadratus menti.

On account of the intimate connection between the skin of the face and the facial muscles, which, from the nature of their insertions, are in some measure identified with it, the frequently repeated contraction of one or more of these muscles occasions folds or wrinkles of the skin, that remain during the intervals of those contractions and after they have entirely ceased. And thus the continual experience of grave or cheerful emotions, with their characteristic expressions of countenance, at length impresses a peculiar and permanent stamp upon the features, so that those who are in the habit of closely observing such circumstances may in some degree judge of the disposition of an individual from an examination of his physiognomy. This is the only foundation of the system of Lavater.

MUSCLES OF THE TEMPORO-MAXILLARY REGION.

The masseter and temporalis.

THE muscles of this region are four in number; two on each side, viz. the masseter and the temporal.

The Masseter.

Dissection. Make a horizontal incision along the zygoma, and a vertical one from the middle of this to the base of the jaw; dissect back the flaps, taking care not to divide the Stenonian duct, which passes over the muscle. In order to see the deep surface, saw through the zygoma in two places, and turn it outwards.

The *masseter* (*s*, *fig.* 113.) is a short and very thick muscle, of an irregularly quadrilateral form, situated upon the side of the face.

Attachments. It *arises* from the lower edge of the zygoma, and is *inserted* into the outer surface of the angle and ramus of the lower jaw. Its origin from the zygoma consists of a very thick aponeurosis, which embraces the anterior borders of the muscles, and is composed of several planes of superimposed fibres, which are prolonged upon its surface and in its substance for a considerable distance. The fleshy fibres proceed from the inferior surface and the borders of this aponeurosis, obliquely *downwards* and *backwards*, and are inserted into the angle of the jaw, either directly or by means of very strong tendinous fibres. Not unfrequently a small triangular fasciculus is detached *forwards* to the inferior border of the body of the bone. The fleshy fibres *arising* from the posterior portion of the zygoma constitute a short, small, and

almost entirely fleshy bundle, which passes *vertically* downwards, and is inserted behind the preceding into the external surface of the ramus of the jaw. Lastly, the zygomatic arch being reversed, we see a still smaller fleshy fasciculus, arising directly from its internal surface, and passing *forwards* to be inserted into the outer surface of the coronoid process, and into the tendon of the temporal muscle.

Relations. It is covered by the skin, from which it is separated by a small fascia, and sometimes by a prolongation of the platysma; behind, it is covered by the parotid gland, and by the orbicularis palpebrarum and zygomaticus major above. It is crossed at right angles by the divisions of the facial nerve, the transverse artery of the face, and the Stenonian duct. It covers the ramus of the jaw, the temporal and the buccinator muscles, from the latter of which it is separated by a collection of fat. Its anterior edge, which is prominent beneath the skin, has an important relation below to the facial artery, which may be compressed against the bone immediately in front of it. The parotid gland embraces its posterior border.

Action. The action of this muscle is very powerful. Its strength in different animals may be in some degree measured by the size of the zygomatic arch, and by the prominence of the lines and projections on the angle of the jaw.

Its momentum, *i. e.* its period of most powerful action, occurs when the jaws are slightly separated, because its angle of incidence with regard to the lever is then nearly perpendicular. The general direction of the fibres of the masseter muscles, obliquely downwards and backwards, is highly advantageous, as regards the trituration of the food, for during the contraction of the two muscles the lower jaw is moved upwards and forwards. This same obliquity explains the action of the muscle in producing luxation of the jaw; for as its insertion is further back than it would have been had the fibres been vertical, it follows that however slightly the jaws may be separated, the condyle is placed in front of the axis to which all the fibres of the masseter may be referred; and when this muscle contracts, it increases the peculiar movement performed by the condyle in becoming dislocated forwards.

The Temporalis.

Dissection. Having sawn through and turned back the zygoma, remove the fascia covering the temporal region, and the fat surrounding the insertion of the muscle into the coronoid process. In order to gain a view of the deep surface, detach the muscle, either from above downwards, by scraping the periosteum from the temporal fossa, or from below upwards, after having sawn through the base of the coronoid process.

The *temporal* muscle (*e'*, *fig.* 114.) or *crotaphyte*, so named because it occupies the whole of the temporal fossa (κρόταφος, the temple), is a broad radiated muscle, resembling a triangle with the base turned upwards.

Attachments. It *arises* from the whole extent of the temporal fossa, and from the inner surface of the superficial temporal fascia, and is *inserted* into the edges and summit of the coronoid process. The fleshy fibres all arise directly, either from the temporal fossa, or from the inner surface of the fascia, which, being attached above to the entire length of the temporal semicircular line, and below to the upper edge of the zygomatic arch, is very tense, and thus affords a solid and very strong surface of origin. From these two parts the fleshy fibres converge, and proceeding downwards, the anterior obliquely backwards, the posterior obliquely forwards, and the middle vertically, form a fleshy mass which gradually increases in thickness until its fibres are attached, partly to the external, but chiefly to the internal surface and borders of the terminal aponeurosis. The fibres of this aponeurosis, which are very strong, and radiated at its commencement, are collected into the form of a very thick tendon, inserted into the coronoid process, and called the *coronoid tendon.* The temporal muscle, in its course from the temporal fossa to the coronoid process,

undergoes a sort of reflexion over the groove at the base of the zygoma. I have often seen a very strong muscular fasciculus arising from the lower part of the temporal fossa and the ridge bounding it below, and inserted by a separate tendon into the internal border of the anterior surface of the ramus of the jaw.

Relations. It is covered by the skin, the aponeurosis of the occipito-frontalis, the anterior and superior auricular muscles, the superficial temporal arteries, veins, and nerves, and more immediately by the superficial temporal aponeurosis, the zygomatic arch, and the masseter. It covers the temporal fossa, the external pterygoid muscle, a small part of the buccinator, the internal maxillary artery, and the deep temporal vessels. Its thickness is in proportion to the depth of the temporal fossa, and the strength of the coronoid process.

Action. The strength of the temporal muscle, therefore, may be in some degree measured by the depth of the temporal fossa, and the size of the coronoid process. This fact may be demonstrated by an examination of these regions in the skeletons of carnivorous animals, in which the elevators of the lower jaw are most highly developed. The use of the temporal muscle, like that of the masseter, is to elevate the lower jaw, but the mechanism of its action is different. In fact, the masseter raises the jaw by a direct action; the temporal muscle, on the contrary, raises it by a sort of *swing motion*, acting principally upon the back part of the coronoid process. In a word, the temporal muscle acts upon the vertical arm of the bent lever represented by the maxillary bone, while the masseter, on the contrary, acts upon its horizontal arm, the movement depending on the action of the temporal muscle: the lower jaw resembles the curved lever represented by the *hammer* of a bell.

THE PTERYGO-MAXILLARY REGION.

The pterygoideus internus. — The pterygoideus externus.

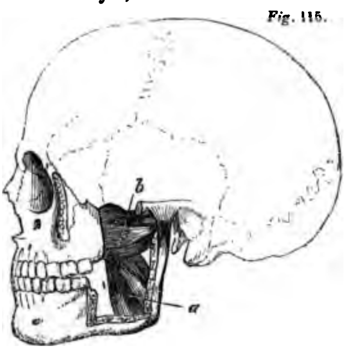
THE muscles of this region are the external and the internal pterygoids.

The Pterygoideus Internus vel Magnus.

Dissection. Separate the face and that part of the cranium which is situated anterior to the vertebral column from the remainder of the skull, and divide the face into two lateral halves by an antero-posterior section.

This muscle may also be dissected in the following manner: saw through the lower jaw vertically at the junction of the body and ramus; remove the zygomatic arch; cut through the base of the coronoid process and the neck of the condyle, and then disarticulate the latter.

Fig. 115.



The *internal pterygoid* (*a*, *fig.* 115.) is deeply seated in the zygomatic fossa, along the inner surface of the ramus of the jaw (tertius musculus qui in ore latitat, *Vesalius*). It is thick, and quadrilateral, and in its form, structure, and direction, bears a remarkable resemblance to the masseter; hence Winslow called it the *internal masseter.*

Attachments. It *arises* from the pterygoid fossa, from the hamular process, at the apex of the internal pterygoid plate, and from the lower surface of the pyramidal process of the palate bone: and is *inserted* into the inner surface of the angle of the lower jaw. Its origin consists of a tendon resembling that of the masseter, prolonged upon the internal surface, and into the substance of the

ıuscle. From this the fleshy fibres proceed *downwards*, *outwards*, and *back-ards*, to be inserted by very strong tendinous laminæ into the lower jaw.

Relations. On the inside it is in relation with the external peristaphyline uscle (*tensor palati*), and with the pharynx, a triangular interval existing be-reen it and the latter, occupied by a considerable quantity of cellular tissue, ssels, nerves, and the sub-maxillary gland: on the outside it corresponds ith the ramus of the lower jaw, from which it is separated above by the ntal and lingual nerves, the inferior dental vessels, and the so-called internal teral ligament of the temporo-maxillary articulation.

Action. As this muscle is inserted almost perpendicularly into the lever upon hich it acts, it has very great power. Most of the remarks already made ncerning the masseter apply to this muscle, which is a true internal mas-ter. It has only this peculiarity, that as its origin is nearer the median line ıan that of the external masseter, it assists in producing a slight lateral move-ent of the jaw, which is very useful in bruising the food.

The Pterygoideus Externus vel Parvus.

Dissection. This, like the preceding muscle, may be exposed by two opposite ethods.

The *external pterygoid* (*b*, *fig.* 115.) is very short, thick, and conoid, smaller ıan the preceding, and situated in the zygomatic fossa, extending horizontally om the outer surface of the external pterygoid plate to the neck of the con-le of the lower jaw. It *arises* from the whole outer surface of the external ate of the pterygoid process, and from the facette of the palatine process, at hich it terminates below, from the ridge separating the temporal and zy-matic fossæ, and from a spinous process at the extremity of this ridge, hich appears to me worthy of notice. It is *inserted* into the fossa in front of e neck of the condyle of the lower jaw, and into the border of the inter-ticular cartilage. Its origin consists of a strong tendon, prolonged into the bstance of the muscle. From this the fleshy fibres proceed horizontally *twards* and *backwards*, forming, at first, two distinct portions, between which e internal maxillary artery often passes: these two portions then converge, e blended together, and terminate by some small tendinous fibres, which form e truncated summit of the cone represented by the muscle, and are attached to e neck of the condyle and to the inter-articular cartilage.

Relations. This muscle is deeply situated, and is in relation on the outside th the ramus of the lower jaw, the temporal muscle, and the internal maxillary tery; on the inside with the internal pterygoid, and above with the upper wall the zygomatic fossa.

Action. The axis of the external pterygoid being directed outwards and ckwards, and its origin being at the pterygoid process, it may be readily ıagined that its contraction will produce a horizontal motion in two direc-ns, viz. forwards and to the opposite side from that on which the muscle is ting. When the two external pterygoids act together, the jaw is carried rectly forwards. From the insertion of this muscle into the inter-articular rtilage, the latter is never separated from the condyle during these several ovements. It is principally this muscle which causes displacement of the ndyle in cases of fracture of the neck of the bone; and it is also the chief ent in bruising the food.

MUSCLES OF THE UPPER EXTREMITIES.

HE muscles of the upper extremities may be divided into those of the ıoulder, of the arm, of the fore-arm, and of the hand.

MUSCLES OF THE SHOULDER.

The deltoideus. — Supra-spinatus. — Infra-spinatus and teres minor. — Subscapularis.

THE muscles of the shoulder are the deltoid, the supra-spinatus, the infra-spinatus and teres minor (which I regard as only one muscle), and the subscapularis. The teres major, generally arranged among the muscles of this region, has already been described with the latissimus dorsi, of which it may be regarded as an accessory.

The Deltoideus.

Dissection. Make a horizontal incision through the skin, round the summit of the shoulder, extending from the external third of the clavicle to the most distant point of the spine of the scapula: from the middle of this incision let another be made, descending vertically half way down the humerus; dissect back the two flaps, taking care to raise at the same time a very thin aponeurosis, which is closely applied to the fibres.

The *deltoid* (*l, figs.* 106. 109.), so named from its resemblance to the Greek *delta* Δ reversed, is a thick, radiated, triangular muscle, bent in such a way as to embrace the scapulo-humeral articulation before, on the outer side and behind. It is the muscle of the top of the shoulder.

Attachments. It *arises* from the entire length of the posterior border of the spine of the scapula, from the external border of the acromion, and from the external third, *i. e.* from the concave part of the anterior border of the clavicle: it is *inserted* into the deltoid impression on the humerus. The scapulo-clavicular origin of the deltoid corresponds exactly to the inferior attachment or the insertion of the trapezius, so that these two muscles, although separate and distinct in man, appear to form a single muscle divided by an intersection; a view that is perfectly confirmed by a reference to comparative anatomy. The origin consists of tendinous fibres; of these the posterior are the longest, and are blended with the infra-spinous aponeurosis, which also gives origin to some of the fibres of the deltoid. Three or four principal tendinous laminæ, attached at regular intervals to the clavicle and the acromion, penetrate into the substance of the muscle, and give origin to a great number of fleshy fibres. The largest of these laminæ extends from the summit of the acromion, and its situation is sometimes indicated by a prominence of the skin, particularly during contraction of the muscle. From this very extensive origin the fleshy fibres proceed downwards, the middle vertically, the anterior backwards, and the posterior forwards: they form a thick broad mass, moulded over the top of the shoulder, and gradually converging, are at length inserted into the deltoid impression of the humerus by three very distinct tendons, the two principal of which, the anterior and posterior, are attached to the bifurcations of that V-shaped impression. Not unfrequently some fibres of the pectoralis major are connected with the front of this tendon.

Relations. It is covered by the skin, the platysma intervening between them, by some supra-acromial nerves, and by a thin fascia extending from the infra-spinous aponeurosis, the spine of the scapula and the clavicle, and becoming continuous with the fascia of the arm. It covers the shoulder joint, from which it is separated by a tendinous layer continued from the infra-spinous aponeurosis and coraco-acromial ligaments, and which terminates on the sheaths of the coraco-brachialis and biceps muscles. Between this lamina and the greater tuberosity of the humerus, there is a quantity of filamentous cellular tissue, and frequently a synovial bursa. The deltoid therefore is inclosed in a proper fibrous sheath, and glides over the articulation. It also covers the upper third of the humerus, the coracoid process, the tendons of the pectorales, coraco-brachialis, biceps, supra-spinatus, infra-spinatus and teres minor, teres major, and biceps muscles, also the circumflex vessels and nerves. The anterior border of the deltoid, directed obliquely downwards and outwards, is separated from the external margin of the pectoralis major by a

cellular interval; but is frequently in contact with it. The cephalic vein and a small artery define the limits of the two muscles. The posterior border is thin above, where it is applied to the infra-spinatus muscle, and becomes thick and free below. The inferior angle of the deltoid is embraced by the brachialis anticus. Issues are generally established over this situation.

Remark. The structure of this muscle has been patiently investigated by some anatomists, who have counted the exact number of its component fasciculi. These are separated by fibro-cellular prolongations, like the fasciculi of the glutæus maximus; sometimes even the muscle is divided into three distinct portions above, viz. a clavicular, an acromial, and a spinal. Eighteen or twenty small penniform fasciculi, the bases of which are generally turned upwards, are collected into a small space by mutually overlapping each other, and are united by their terminating tendons. Albinus admits ten of these bundles which he has described separately.

Action. The deltoid elevates the shoulder (*elevator, attollens humerum*). From the threefold direction of its fibres, it has a different action, according to the particular set of fibres employed. The middle fibres raise the humerus directly, the anterior raise and carry it forwards, the posterior raise and carry it backwards. When the arm is raised, Bichat states that the anterior and posterior fibres can depress it; but I do not think this possible. There has been no example recorded of luxation from the over action of this muscle. When the arm is fixed, as in the act of climbing, the shoulder is moved upon the head of the humerus. The trapezius must be regarded as the most powerful antagonist of the deltoid, since the scapulo-clavicular attachments of both muscles are the same. Thus we have seen that the diaphragm and the transversalis abdominis are separated only by their costal insertions. The most complete antagonism follows from such an arrangement, for then one fibre is, as it were, opposed to another, having exactly an opposite direction.

The action of the deltoid is however less powerful than might have been supposed from its size; it is, in fact, parallel to the lever on which it acts. Whilst almost all other muscles have a *momentum*, occurring at the period when their fibres are inserted at the most favourable angle, the deltoid, properly speaking, has none; it is parallel to the lever during the entire period of its action. This is the reason why the elevation of the arm is so feeble a movement; and why contraction of the deltoid is always accompanied by considerable fatigue.

The Supra-spinatus.

Dissection. Take off the trapezius, and in order to see the whole extent of the muscle, remove the clavicle, and saw through the base of the acromion.

The *supra-spinatus* (*r, fig.* 106.) is a thick triangular muscle, broad on the inside, narrow without, occupying the supra-spinous fossa, and retained therein by a strong aponeurosis, which completes the osteo-fibrous sheath in which the muscle is inclosed.

Attachments. It *arises* from the internal two thirds of the supra-spinous fossa, and is *inserted* into the highest of the three facettes on the greater tuberosity of the humerus. Its origin from the supra-spinous fossa is partly tendinous and partly fleshy, and some fibres arise from its aponeurotic investments. From these points the fleshy fibres converge to a tendon, which is found among them, where the muscle reaches the upper part of the joint, and which is slightly reflected over the head of the humerus before reaching its insertion. This has not the shining appearance of other tendons, but has the dull aspect of many ligaments; it is blended with the fibrous articular capsule, from which it cannot be separated near its insertion. It may even be regarded as forming the upper part of the capsular ligament.

Relations. It is covered by the trapezius, the clavicle, the coraco-acromion ligament, and the deltoid; and it covers the supra-spinous fossa, the supra-

scapular vessels and nerves *, and the upper part of the shoulder joint. Its tendon is often blended with that of the infra-spinatus, and is separated from that of the sub-scapularis by the long head of the biceps, and the accessory ligament of the capsule.

Action. It raises the humerus, and therefore assists the deltoid. Notwithstanding the number of its fibres, and its perpendicular insertion into its lever, it has very little power, on account of the proximity of that insertion to the fulcrum. Its principal action appears to me to have reference to the joint, affording a support to it above, and forming a sort of active arch, the resisting power of which is in proportion to the force tending to thrust the humerus upwards against the osteo-fibrous arch, composed of the acromion and coracoid processes and their connecting ligament. There is no muscle then to which the name of *articular* can be more correctly applied. The use of the deep fibres in preventing the folding of the fibrous and synovial capsules, and their compression between the two articular surfaces, though much insisted on by Winslow, appears to me very problematical.

The Infra-spinatus and Teres Minor.

Dissection. Detach the scapular origin of the deltoid, and saw through the base of the acromion.

The *infra-spinatus (s) and teres minor (t, fig.* 106.) constitute a single, thick, triangular muscle, broad on the inside and narrow externally, and occupying the infra-spinous fossa, in which it is retained by an aponeurosis, exactly resembling that of the supra-spinatus muscle.

It *arises* from the internal two thirds of the infra-spinous fossa, from a very strong fascia interposed between it and the teres major and long head of the triceps, and by a few fibres from the infra-spinous aponeurosis: it is *inserted* into the middle and inferior facettes on the greater tuberosity of the humerus, below the insertion of the supra-spinatus. It arises from the infra-spinous fossa, directly by fleshy fibres, and also by means of tendinous fibres attached along the ridges of that fossa. One of these laminæ is constantly found attached to the ridge situated on the outer side of the infra-spinous groove: this has doubtless given rise to the division of the muscle into two parts, called the infra-spinatus and the teres minor. From these origins the fleshy fibres proceed, the superior horizontally, the next obliquely, and the inferior almost vertically outwards: they form a thick, triangular, fleshy body, and become attached to the anterior surface and margins of a flat tendon, which glides upon the concave humeral border of the spine of the scapula, to be inserted into the humerus. Not unfrequently we find the lower fibres of the portion called the teres minor, arising from the posterior surface of the tendon of the triceps, becoming applied to the under part of the capsular ligament, and inserted into the humerus immediately below the greater tuberosity.

Relations. These two united muscles are covered by the deltoid, the trapezius, the latissimus dorsi, and the skin; and they cover the infra-spinous fossa, from which they are separated by the supra-scapular nerves and vessels; they also cover the capsular ligament of the joint, and a small portion of the long head of the triceps. Their lower or external border corresponds internally or inferiorly with the teres major, an aponeurotic septum intervening between them, and externally or superiorly with the long head of the triceps.

Action. This muscle rotates the humerus outwards and a little backwards. When the arm is raised, it assists in keeping it in this position, and carries it backwards. But an important use of this muscle is that of retaining the head of the humerus in its place, preventing its displacement backwards, and protecting the posterior part of the articulation.

* The supra-scapular nerve generally passes through the coracoid notch by itself, and the supra-scapular artery above the ligament.

The Sub-scapularis.

ction. Detach the upper extremity, including the shoulder, from the f the body; remove from the inner surface of the muscle the cellular he lymphatic glands, the brachial plexus, the axillary vessels, and the magnus; and dissect off, with care, the thin fascia which invests it.

sub-scapularis (*o, figs.* 110. 116.) is a thick triangular muscle, occu- the whole of the sub-scapular fossa, beneath the axillary border of t passes: by itself it represents the supra- and infra-spinatus and teres upon the posterior scapular region. We not unfrequently meet with us laminæ dividing it into three parts, which correspond to those three i.

:hments. It *arises* from the internal two thirds of the sub-scapular y tendinous laminæ attached to the oblique ridges already described as g on that part of the scapula; also from the anterior lip of the axillary of the scapula by an aponeurosis, which separates this muscle from the iajor and the long head of the triceps. Very frequently the lowest rise from the anterior surface of this head of the triceps, just as we en that the lower fibres of the teres minor take their origin from the or surface of the same head of that muscle. From these different the fleshy fibres all proceed outwards, the upper horizontally, and the bliquely, gradually approaching more and more to the vertical direc- The muscle therefore becomes progressively narrower and thicker, s fibres are attached to the two surfaces and borders of a tendon which *rted* into the entire surface of the lesser tuberosity of the humerus. f the muscular fibres are inserted below the tuberosity; and I have e inferior fibres of the muscle attached for a certain extent to a fibrous ation that completes the bicipital groove behind.

tions. The posterior surface of this muscle lines the sub-scapular fossa, it entirely fills, and from which it is separated at the outer third by ellular tissue and the sub-scapular vessels and nerves; more externally, rs the upper and anterior part of the capsular ligament of the shoulder urning around it, and becoming identified with it at its insertion. Its *surface* is in relation with the serratus magnus, the sub-scapular fascia ne very loose cellular tissue intervening between them; also with the r vessels and nerves, and with the coraco-brachialis and deltoid muscles. *per border* of its tendon glides in the hollow of the coracoid process, serves as a pulley, and forms with the coraco-brachialis and the short the biceps a sort of ring, partly bony and partly muscular, in which don is retained. Between this tendon and the coracoid process there is ynovial bursa, which sometimes extends over the tendons of the biceps aco-brachialis, and always communicates with the synovial capsule of ulder joint.*

n. It is essentially a rotator inwards of the humerus. In proof of this that the muscle is stretched when the arm is rotated outwards, and when it is rotated inwards. The movement of rotation is much more rable than the length of the neck of the humerus would lead us to ;, and this arises from the muscle turning round the head of the bone. tator muscle, then, it is congenerous with the latissimus dorsi. When nerus is raised, the sub-scapularis tends to draw it downwards. And this muscle as well as the supra-spinatus, infra-spinatus, and teres is essentially an articular muscle, and is sometimes completely identified e anterior part of the fibrous capsule: in all cases it offers an active ce to displacement forwards, and is therefore always torn in this kind cation.

* See note, p. 389.

MUSCLES OF THE ARM.

The biceps. — *Brachialis anticus.* — *Coraco-brachialis.* — *Triceps extensor cubiti.*

THE muscles of the arm have been divided into those of the *anterior region*, viz. the biceps, the coraco-brachialis, and the brachialis anticus; and those of the *posterior region*, which constitute the single muscle called the triceps.

ANTERIOR BRACHIAL REGION.

The Biceps.

Dissection. Make a vertical incision through the skin from the middle of the clavicle to the middle of the bend of the elbow; dissect back the flaps, and divide longitudinally the brachial fascia, which is united to the biceps by very loose cellular tissue; preserve the vessels and nerves which lie along the inner border of the muscle. Expose the upper part of the muscle by detaching the pectoralis major and deltoid from their clavicular origins, and turning them inwards and outwards. In order to trace the whole extent of the long head of the biceps, open the capsular ligament above; and to see the radial insertion of the muscle, flex the fore-arm to a right angle upon the arm, and supinate it forcibly; it is better, however, to wait until the muscles of the anterior region of the fore-arm are dissected.

The *biceps flexor cubiti* (*a*, *fig.* 116.) is a long muscle forming the superficial layer of the anterior region of the arm; it is divided above into a *short* and *long* head*; and hence its name *biceps.*

Fig. 116.

Attachments. It *arises* by its short head from the apex of the coracoid process, and by its long head from the top of the glenoid cavity; and is *inserted* into the bicipital tuberosity of the radius.

The origin of the *short* or *coracoid* head (*b*, *fig.* 116.) consists of a flat and very thick tendon, common to it and the coraco-brachialis, and terminating in front of this part of the muscle in an aponeurosis, from which is given off a tendinous septum, between the biceps and the coraco-brachialis. The *long*, *glenoid*, or *reflected* head arises by a tendon apparently forming a continuation of the glenoid articular border, which penetrates into the interior of the joint, turns over the head of the humerus upon which it is reflected, and thus reaches the bicipital groove. It is retained in this groove by a sort of fibrous bridge or canal, traverses the whole of its extent, and ends in a sort of tendinous cone open behind, from the interior of which the fleshy fibres take their origin. These fibres are collected into a rounded belly, which, about the middle of the arm, is applied to the muscular belly of the short portion, equally rounded and of variable size, and ultimately becomes identified with it. The single muscle (*a*, *fig.* 116.), thus formed, is very thick, flattened from before backwards, and directed vertically like the two original fasciculi. Its fibres are attached to the surfaces and edges of an aponeurosis, which gradually becomes narrower and thicker until it emerges in the form of a free tendon opposite the lower end of the humerus, a little nearer to the outer than the inner side. This flattened tendon sinks downwards and

* Not unfrequently the biceps is trifid above. The supernumerary head is internal, and arises from the inner border of the humerus, below the coraco-brachialis, which may be regarded as the continuation of this head, for they correspond in size. This supernumerary portion is attached to the inner edge and posterior surface of the lower tendon of the biceps. I have twice seen this disposition of parts.

ıckwards into the triangular space between the supinator longus and the proıtor teres, and is then so folded and twisted upon itself that its anterior surce becomes posterior, its internal margin becomes anterior, and its external argin at first posterior and then superior. This folding and torsion are of ιtreme utility in preventing displacement of the muscle, which thus fastens ›wn itself. The tendon of insertion having given off from its anterior surface ıd external margin a broad aponeurosis, constituting the principal origin of the scia of the fore-arm, glides over the bicipital tuberosity of the radius, from hich it is separated by a bursa, and is inserted into the posterior part of that rocess.

Relations. The upper third of the two heads of the biceps as well as the oraco-brachialis, and the axillary vessels and nerves, are contained in the ıvity of the axilla, between the pectoralis major and the deltoid in front, and he latissimus dorsi and teres major behind. In this part of its course the hort head of the biceps is in relation with the coraco-brachialis on the inside, nd behind with the sub-scapularis, which separates it from the shoulder-joint; ı bursa intervenes between these two muscles. The tendon of the long head ıs in contact with the head of the humerus, and surrounded by the synovial membrane, which isolates it from the cavity of the joint, and accompanies it for a greater or less distance along the bicipital groove. Below the axilla the biceps is subcutaneous *in front*, the brachial fascia intervening between it and the skin, through which it is very clearly defined; *behind*, it is in relation with the musculo-cutaneous nerve, and the coraco-brachialis and brachialis anticus muscles; *on the inside*, with the brachial artery and its accompanying veins and with the median nerve, all of which lie along its internal border, by the projection of which they are protected. The tendon is embraced at its insertion by the supinator brevis, and it is separated from that of the brachialis anticus by a bursa. Great attention should be paid to the relation of this muscle to the brachial artery. I am accustomed, when speaking of the surgical anatomy of these parts, to call the biceps the satellite muscle of the brachial artery. It is worthy of remark, that the relative positions of the long and the short head are altered as the humerus is rotated inwards or outwards; in rotation inwards the long head is placed behind the other, or even crosses to the inner side or it; but in rotation outwards the interval between the two heads is considerably increased.

Action. The biceps flexes the fore-arm upon the arm, and at the same time supinates it. This last effect results from the insertion of the muscle into the inner and back part of the bicipital tubercle of the radius. The *momentum* of the biceps occurs during semi-flexion of the fore-arm; its insertion being at that period perpendicular to the lever, the disadvantage arising from its proximity to the fulcrum is then counteracted. The length of its fibres explains the extent of the movement of flexion. By means of its scapular attachments the biceps acts upon the arm, either secondarily, after bending the fore-arm, or primarily, when the fore-arm is extended. By means of both its heads it carries the arm forwards, and thus co-operates with the anterior fibres of the deltoid and coraco-brachialis. The two heads also assist in strengthening the shoulder joint. The long head forms a sort of fibrous arch, which supports the head of the humerus and retains it in the glenoid cavity. The short head, together with the coraco-brachialis, forms a continuation of the hook of the coracoid process, and protects the anterior and inner part of the joint.

The biceps is, as Winslow first showed, one of the principal supinators of the fore-arm; and it is in this movement that the tendon glides over the bicipital tuberosity of the radius by means of the intervening bursa. This tuberosity is almost entirely intended for the tendon to glide over; it is therefore incrusted with cartilage. Dense and reddish granulations, as pointed out by Haller, are found upon the synovial bursa of the tendon.

When the fore-arm is fixed, as in climbing, the biceps flexes the arm upon

the fore-arm, and the scapula upon the arm. Lastly, it is a tensor of the fascia of the fore-arm, upon which the internal fibres of the muscle often terminate.

The Brachialis Anticus.

Dissection. Cut the biceps across, opposite the insertion of the deltoid, and turn down the lower part upon the fore-arm.

The *brachialis anticus* (brachialis internus, *Alb.*, *d d*, *fig.* 116.; *d*, *fig.* 117.) is a thick, prismatic, and triangular muscle, situated behind the preceding. It *arises* from the humerus below the insertion of the deltoid, which it embraces by a well-marked bifurcation; and since the point of insertion of the deltoid is not always the same, it follows that this origin of the brachialis anticus is also variable: it also arises from the internal and external surfaces, and from the three borders of the humerus, and from the external and internal inter-muscular septa. It is *inserted* into the rough surface on the fore part of the coronoid process of the ulna. The different origins from the humerus are fleshy, the fibres being of very various lengths, and proceeding in different directions; the middle pass vertically downwards, the external somewhat obliquely inwards, and the internal outwards; they all terminate on the posterior surface of an aponeurosis, which is broad and thin above, and thick below, especially on the outer side, where it turns round so as to embrace the outer border of the muscle, and forms a deep aponeurotic lamina. The fleshy fibres therefore are received into a semi-cone of tendinous substance open on the inside, the fibres of which are collected together and finally inserted into an oblique line, running downwards and outwards, below the coronoid process of the ulna.

Relations. The *anterior surface* of the brachialis anticus is in relation with the biceps, the musculo-cutaneous nerve, the brachial fascia, the brachial artery and veins, and the median nerve; its *internal surface*, with the pronator teres muscle, the ulnar nerve, and the triceps, from which it is only separated by the internal inter-muscular septum; its *external surface*, with the supinator longus and the extensor carpi radialis longior, which are received into a sort of groove presented by it, the radial nerve establishing the limit between these two muscles and the brachialis anticus. The *posterior surface* embraces the internal and external surfaces of the humerus, to which it is attached; below, it embraces and effectually protects the front of the elbow joint, into the anterior ligament of which many of its fibres are inserted.

Action. The brachialis anticus flexes the fore-arm upon the arm, and reciprocally the arm upon the fore-arm. Its *momentum* takes place, like that of the biceps, during semi-flexion. It is worthy of remark that this muscle acts with greater precision than the biceps upon the fore-arm, because it arises from the humerus only, and besides that it belongs more especially than that muscle to the elbow joint. I have already said that it may be regarded as the active anterior ligament of this articulation. In fact it so completely limits the movement of extension, that we cannot imagine the possibility of luxation of the fore-arm backwards, without rupture of this muscle. From the insertion of the biceps into the radius, and of the brachialis anticus into the ulna, it follows that the flexor muscles of the fore-arm are divided between the two bones, in the same manner as those of the leg are distributed to the tibia and fibula. Thus, the contraction of the brachialis anticus has a tendency to carry the fore-arm outwards as well as to flex it, while that of the biceps tends to draw it inwards. When the two muscles contract simultaneously, direct flexion is the result.

The Coraco-brachialis.

Dissection. The upper part is exposed as soon as the deltoid is detached; the middle is situated between the pectoralis major and the latissimus dorsi; and the lower part is seen upon the inner surface of the humerus near the tendon of the deltoid.

oraco-brachialis (*e*, *figs.* 116, 117.) is the smallest muscle of the arm. iated at the inner and upper part of the arm, and was confounded by the older anatomists with the short head of the biceps, with which t is intimately united at its upper part.

hments. It *arises* from the apex of the coracoid process, and is *in*- wards the middle of the internal surface and border of the humerus. from between two tendinous layers, the most superficial of which is to it and the short head of the biceps, and also from the septum these two muscles. From this origin the fleshy fibres proceed, an elongated, thin, and flat bundle, the size of which is always in an ratio to that of the short head of the biceps; this bundle passes down- backwards, and a little outwards, to be inserted into the humerus, the brachialis anticus and the triceps. Its insertion is effected by f a flat tendon, which receives the fleshy fibres successively upon its nd external surface, and is accompanied by them even to its attach- the bone. The precise situation of the attachment varies like that leltoid, and hence the different statements of authors regarding this According to Winslow, the coraco-brachialis is inserted at the upper the middle third of the humerus; according to M. Boyer, in the of the bone; and, according to Bichat, a little above its middle. I have inserted at the junction of the lower with the two upper thirds.

ions. It is covered by the deltoid, the pectoralis major, and the biceps, overs the sub-scapularis, the latissimus dorsi, and the teres major. Its s to the axillary and brachial arteries and the median and musculo- us nerves are the most important. Above, it covers these parts, and is in relation with the outer side of the brachial artery and median so that its tendon alone separates the vessel from the bone. The -cutaneous nerve passes through it; hence the name of *perforatus Casserii* n given to this muscle. It is also very frequently perforated by one of iches of origin or roots of the median nerve.

s. It carries the arm forwards and inwards, and at the same time it. It co-operates with the anterior fibres of the deltoid, and the fibres of the pectoralis major. If the arm be fixed, it depresses the he shoulder; when the arm is carried backwards and turned inwards, it forwards again, and rotates it outwards.*

Posterior Brachial Region.

The Triceps Extensor Cubiti.

ction. It is exposed by simply removing the skin and the fascia from k of the arm, by removing the deltoid, or turning it upwards, and by the long head of the muscle between the teres major and minor to the border of the scapula. In order to render it tense, and thus facilitate ection, the fore-arm must be flexed, and the humerus abducted.

riceps extensor cubiti (*i f g*, *fig.* 117.) is a very large muscle, divided nto three portions, named the external, internal, and middle, or long It constitutes by itself the entire muscular apparatus of the posterior of the arm.

hments. It *arises*, 1. by its *long head*, from the lower part of the gle- ity of the scapula, and from a rough triangular depression existing on tiguous portion of its axillary border; 2. by its *external head* (vastus s) from all that portion of the posterior surface of the humerus which

re seen a small supernumerary coraco-brachialis extending from the base of the co- ocess to below the lesser tuberosity of the humerus, immediately beneath the inser- e sub-scapularis: the same arrangement existed on both sides. This small muscle a curve in front of the sub-scapularis.

is above the groove for the radial nerve, from the external border of that bone, and from the external inter-muscular septum; 3. by its *internal head* (vastus internus) from the whole of the posterior surface of the humerus below the groove for the radial nerve, from the internal border of the bone and from the internal inter-muscular septum. It is *inserted* into the back of the olecranon.

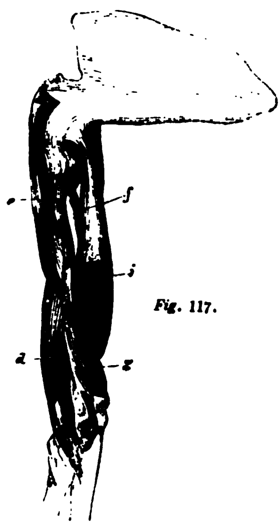


Fig. 117.

The origin of the middle or long head (which we shall find to be analogous to the rectus cruris) *, consists of a tendon that is blended with the glenoid ligament, nearly in the same manner as the long tendon of the biceps. This tendon is flattened from before backwards, and soon splits into two layers, united by their outer edges, the posterior of which is thin and short, while the anterior is very thick, especially at its outer edge, and prolonged to the middle of the muscle. The head of the humerus, therefore, is bound by the long head of the triceps below, in the same manner as by the long tendon of the biceps above. The fleshy fibres arise from between the two layers above mentioned, and form a bundle flattened in front and behind, which immediately turns upon itself, so that its anterior surface becomes posterior, and *vice versâ*. From this sort of torsion the strongest layer of the tendon, which was originally in front, eventually occupies the posterior surface of the muscle. The fleshy fibres arising from between the two layers, and especially from the anterior surface and borders of the *now* posterior tendon, pass downwards and a little outwards, to be inserted, some into the anterior but the greater number into the posterior surface of an aponeurotic expansion, the external border of which is continuous with a similar structure belonging to the external division of the muscle. The aponeurotic fibres are collected together into a very thick tendon, which is folded into a semi-cone, within which the fleshy fibres terminate; the tendon itself is inserted by a thick mass into the inner and back part of the olecranon, on the outer side of the internal portion of the muscle, and closely united with the posterior aponeurosis of the external portion. A synovial capsule intervenes between this tendon and the olecranon.

The origins of the external and internal portions from the humerus divide between themselves, so to speak, the posterior surface of that bone, to which the long head has no attachments.

The *external head* (*f*, *figs.* 116, 117.), which is larger than the internal, and from analogy may be termed the *vastus externus* of the triceps brachii (cubitum extendentium secundus, *Vesalius;* anconé externe, *Winslow*), arises partly by fleshy and partly by tendinous fibres. They are bounded above by a rough line, which is very well-marked in powerful individuals, extending obliquely from the lower part of the head of the humerus to its external border. From these different origins the fleshy fibres proceed downwards and inwards, become partly blended with the internal head, and are almost all attached to the anterior surface of the terminal aponeurosis of the long head, and to the anterior surface and external edge of a very broad and strong tendon, which occupies the posterior aspect of the muscle. This latter tendon is united internally with the tendon of the long head, is folded upon itself, and receives the fleshy fibres as far as its insertion into the olecranon, on the outside of the long head.

* The older anatomists regarded this long portion as a separate muscle: longus (*Riolanus Albinus*), cubitum extendentium primus (*Vesalius*), le grand anconé (*Winslow*).

The inferior fleshy fibres of this portion of the muscle are very short and horizontal, and seem to be continued by the anconeus.

The *internal head* of the triceps (tertius cubitum extendentium, *Vesalius;* anconé interne, *Winslow, g, figs.* 116, 117.), which we denominate the *vastus internus* of the triceps brachii, might be called *the deep and internal portion* of this muscle, for, as we find with regard to the vastus internus of the thigh, it is almost entirely covered by the other two portions. Its origins are partly fleshy and partly tendinous. The fibres pass in different directions, the external downwards and inwards, a few to the anterior surface of the aponeurosis of the external head, by which they are concealed, but the greater number directly to the olecranon, in front of the insertion of the other portions. The internal pass downwards and outwards, and terminate, some upon the inner edge and anterior surface of the tendon of the long head, but the greater number directly upon the olecranon, to the inside of that tendon. The lowest of these fibres are almost horizontal. Some of the deepest fasciculi are generally given off from the body of the muscle to be inserted into the synovial capsule of the elbow joint.

Relations. It is covered through nearly its whole extent by the brachial fascia, and separated by it from the skin, through which it is distinctly defined; it covers the posterior surface of the humerus, the back of the elbow joint, the radial nerve, and the deep humeral artery. It is separated from the muscles of the anterior region of the arm by the external and internal intermuscular septa. Its long or scapular portion is in relation with the deltoid and the teres minor behind, and with the sub-scapularis, the teres major, and the latissimus dorsi in front.

Action. The triceps extends the fore-arm upon the arm, but in order that its long head may act with effect, the scapula must be fixed by other muscles. The power of this muscle is not so great as its size and the number of its fibres would indicate, on account of its disadvantageous insertion near the fulcrum. It is true that here, as in the case of the triceps femoris, nature has as much as possible counterbalanced this disadvantage by inserting the muscle, not into the apex, but into the back part of the olecranon. We even find, as we have said, a synovial bursa between the tendon and that part of the olecranon with which it is in contact. It would appear, at first sight, that the *momentum* of this muscle would occur during semi-flexion, but a little consideration would show, that, like the triceps femoris, it has, properly speaking, no momentum; and that the olecranon, which may be regarded as the ossified tendon of the muscle, always has the same relation to the ulna, whatever be the position of the fore-arm. It should also be observed, that this muscle has not nearly so much power during semi-flexion as during extension, because in the former case it is opposed by the flexor muscles, which in that position act with the greatest possible effect; while in the latter, when the arm and fore-arm form an obtuse angle, the extensor muscle has the advantage. Lastly, the predominance of the extensor over the flexors is less marked in the arm than in the thigh; and even supposing the extensor to possess more intrinsic power, it has less active force, in consequence of the insertions of the flexors being much more favourable, both as regards their distance from the fulcrum, and their nearer approach to a perpendicular direction. Thus flexion evidently predominates at the elbow, and extension at the knee. This, indeed, ought to be the case, for in the upper extremities the flexion of the elbow is the movement of attraction and prehension; whilst in the lower extremities the extension of the knee is an essential position in standing, walking, running, and leaping.

We might suppose the possibility of rupture of the olecranon at its junction with the coronoid process during violent extension of the fore-arm, an accident that would be analogous to fracture of the patella, or rupture of its ligament. The long head of the triceps assists in drawing the humerus backwards, and slightly adducts the arm. By means of its tendon of origin from

the scapula, and especially by the outer edge of that tendon, which is thick and as it were arched, so as to fit the head of the humerus, the long head also forms a cord which supports the bone during abduction, and tends to prevent its displacement; but as the glenoid cavity is directed forwards, and as its inferior extremity is situated almost at the junction of the two anterior thirds with the posterior third of the cavity, it follows that this tendon is well calculated to prevent dislocation backwards, but offers no resistance to displacement forwards. Sometimes the lower extremity of the triceps becomes its fixed point, and then it extends the arm upon the fore-arm, and the shoulder upon the arm.

MUSCLES OF THE FORE-ARM.

The pronator teres. — *Flexor carpi radialis.* — *Palmaris longus.* — *Flexor carpi ulnaris.* — *Flexor sublimis digitorum.* — *Flexor profundus digitorum.* — *Lumbricales.* — *Flexor longus pollicis.* — *Pronator quadratus.* — *Supinator longus.* — *Extensores carpi radialis, longior et brevior.* — *Supinator brevis.* — *Extensor communis digitorum.* — *Extensor digiti minimi.* — *Extensor carpi ulnaris.* — *Anconeus.* — *Abductor longus pollicis.* — *Extensor brevis pollicis.* — *Extensor proprius indicis.*

The muscles of the fore-arm are divided into those of the anterior, the external, and the posterior regions.

Muscles of the Anterior Region.

These muscles form four very distinct layers. The first consists of the pronator teres, the flexor carpi radialis, the palmaris longus, and the flexor carpi ulnaris; the second is formed by the flexor sublimis digitorum; the third by the flexor profundus digitorum and the flexor longus pollicis; and the fourth by the pronator quadratus.

The Pronator Teres.

Dissection. This muscle is exposed when the inner and anterior part of the fascia of the fore-arm is removed. Its origin should be carefully studied.

Fig. 118.

The *pronator teres* or *rotundus* (*a*, *fig.* 118.), the most superficial muscle on the anterior and inner aspect of the fore-arm, forms an oblique ridge under the skin, upon the inner side of the bend of the elbow. It is *attached* above to the inner condyle of the humerus, or epitrochlea (*a*, *fig.* 119.), and is *inserted* below into the middle of the radius (*a'*). It arises from the lower part of the inner border of the humerus, from the inner condyle, from a large intermuscular septum separating it from the flexor carpi radialis and the flexor sublimis, and from the coronoid process of the ulna on the inner side of the brachialis anticus, by means of a tendinous and fleshy bundle, which is separated from the rest of the muscle by the median nerve. From these origins the fleshy fibres proceed obliquely downwards and outwards (pronateur oblique, *Winsl.*), surrounding a flat tendon, which appears first on the anterior surface of the muscle and then turns over the anterior and external surfaces of the radius, to be inserted at the middle of that bone. The muscle therefore turns spirally around the radius, but not so completely as the supinator brevis. Its insertion may take place opposite any point in the middle third of the bone.

Relations. It is covered by the fascia of the fore-arm, by the supinator longus and extensor carpi radialis, and by the radial artery and musculo-spiral nerve: it covers the brachialis anticus and flexor sublimis, the median nerve by which it is first perforated, and the ulnar artery.

Action. The greater the amount of supination of the fore-arm, the more effectual is the action of this muscle as a pronator, because then it is much

more completely rolled around the radius. I may remark, that on account of its obliquity it is inserted into the radius at an angle of 45°; and that, consequently, the direction in which it operates is rather favourable. It acts with greater advantage in proportion as it is inserted nearer to the upper end of the radius; and, for this reason, its power must vary considerably in different individuals. When pronation is carried as far as possible, the muscle then becomes a flexor of the fore-arm. After the preceding examination of this muscle, we need no longer be surprised at the great energy of the movement of pronation, which is much more powerful than that of supination; nor yet that it is the most natural position of the fore-arm, for the pronator teres can more than counteract the two supinators taken together. In fracture of the bones of the fore-arm, this muscle tends to obliterate the interosseous space.

The Flexor Carpi Radialis.

Dissection. It is sufficient to divide and dissect off the anterior part of the fascia of the fore-arm, in order to expose this muscle, which may be recognised by the following description: —

The *flexor carpi radialis* (radialis internus, *Albinus*, *b*, *fig.* 118.) is situated immediately within the pronator teres, occupying the superficial layer of the anterior aspect of the fore-arm, and being, as far as its tendon is concerned, the most superficial of all these muscles. It *arises* from the lower part of the internal border and from the inner condyle of the humerus (*b*, *fig.* 119.), and is *inserted* (*b'*) into the second metacarpal bone. Its origin consists of a tendon common to it and to the pronator quadratus, palmaris longus, flexor sublimis, and flexor carpi ulnaris. The fleshy fibres immediately arise from within a sort of pyramidal aponeurosis given off by this common tendon, and from the body of the muscle, at first slender, then increasing in size, and again tapering towards its attachment to the two surfaces and edges of a tendon, which forms the lower two thirds of the muscle, and passes obliquely outwards and downwards to the level of the os scaphoides; it there penetrates into a groove formed by the scaphoid and the trapezium, is reflected inwards along this oblique groove, and terminates upon the second metacarpal bone, spreading out so as to embrace its upper extremity; it also gives off a tendinous expansion to the trapezium, and sometimes one to the third metacarpal bone.

Relations. It is covered by the fascia and the skin, through which it is very clearly defined: it is in relation behind with the flexor sublimis; on the outside with the tendon of the flexor pollicis, over which it passes at an acute angle so as to bind it down; and lower down with the wrist joint. A very strong tendinous sheath, concealed by the abductor brevis and opponens pollicis, completes the groove formed by the scaphoid and trapezium for its tendon, the movements of which are facilitated by a well marked synovial membrane.* Its most important relation is that of the external border of its tendon with the radial artery. The superficial position of the tendon prevents our feeling the artery when the muscle is contracted.

Action. It flexes the second row of the carpus upon the first, and this again upon the fore-arm. Moreover, on account of its reflexion, it is a pronator, and, according to Winslow, it is a more powerful supinator than the supinator longus. Its obliquity downwards and outwards explains why it inclines the hand to the radial border of the fore-arm, and thus acts as an abductor.

The Palmaris Longus.

Although this small muscle is rather a tensor of the palmar fascia than a flexor of the hand, I have yet judged it proper to describe it in this place, in connection with the flexor carpi radialis, which, in contradistinction to this

* See note, p. 389.

MUSCLES OF THE SHOULDER.

The deltoideus. — *Supra-spinatus.* — *Infra-spinatus and teres minor.* — *Subscapularis.*

THE muscles of the shoulder are the deltoid, the supra-spinatus, the infra-spinatus and teres minor (which I regard as only one muscle), and the sub-scapularis. The teres major, generally arranged among the muscles of this region, has already been described with the latissimus dorsi, of which it may be regarded as an accessory.

The Deltoideus.

Dissection. Make a horizontal incision through the skin, round the summit of the shoulder, extending from the external third of the clavicle to the most distant point of the spine of the scapula: from the middle of this incision let another be made, descending vertically half way down the humerus; dissect back the two flaps, taking care to raise at the same time a very thin aponeurosis, which is closely applied to the fibres.

The *deltoid* (*l, figs.* 106. 109.), so named from its resemblance to the Greek *delta* Δ reversed, is a thick, radiated, triangular muscle, bent in such a way as to embrace the scapulo-humeral articulation before, on the outer side and behind. It is the muscle of the top of the shoulder.

Attachments. It *arises* from the entire length of the posterior border of the spine of the scapula, from the external border of the acromion, and from the external third, *i. e.* from the concave part of the anterior border of the clavicle: it is *inserted* into the deltoid impression on the humerus. The scapulo-clavicular origin of the deltoid corresponds exactly to the inferior attachment or the insertion of the trapezius, so that these two muscles, although separate and distinct in man, appear to form a single muscle divided by an intersection; a view that is perfectly confirmed by a reference to comparative anatomy. The origin consists of tendinous fibres; of these the posterior are the longest, and are blended with the infra-spinous aponeurosis, which also gives origin to some of the fibres of the deltoid. Three or four principal tendinous laminæ, attached at regular intervals to the clavicle and the acromion, penetrate into the substance of the muscle, and give origin to a great number of fleshy fibres. The largest of these laminæ extends from the summit of the acromion, and its situation is sometimes indicated by a prominence of the skin, particularly during contraction of the muscle. From this very extensive origin the fleshy fibres proceed downwards, the middle vertically, the anterior backwards, and the posterior forwards: they form a thick broad mass, moulded over the top of the shoulder, and gradually converging, are at length inserted into the deltoid impression of the humerus by three very distinct tendons, the two principal of which, the anterior and posterior, are attached to the bifurcations of that V-shaped impression. Not unfrequently some fibres of the pectoralis major are connected with the front of this tendon.

Relations. It is covered by the skin, the platysma intervening between them, by some supra-acromial nerves, and by a thin fascia extending from the infra-spinous aponeurosis, the spine of the scapula and the clavicle, and becoming continuous with the fascia of the arm. It covers the shoulder joint, from which it is separated by a tendinous layer continued from the infra-spinous aponeurosis and coraco-acromial ligaments, and which terminates on the sheaths of the coraco-brachialis and biceps muscles. Between this lamina and the greater tuberosity of the humerus, there is a quantity of filamentous cellular tissue, and frequently a synovial bursa. The deltoid therefore is inclosed in a proper fibrous sheath, and glides over the articulation. It also covers the upper third of the humerus, the coracoid process, the tendons of the pectorales, coraco-brachialis, biceps, supra-spinatus, infra-spinatus and teres minor, teres major, and biceps muscles, also the circumflex vessels and nerves. The anterior border of the deltoid, directed obliquely downwards and outwards, is separated from the external margin of the pectoralis major by a

of the carpus upon the first, and this upon the fore-arm; at the same time it inclines the hand towards its ulnar side. Its *momentum*, as well as that of the preceding muscle, occurs during semi-flexion of the hand upon the fore-arm.

The Flexor Sublimis Digitorum.

Dissection. The portion of this muscle, situated in the fore-arm, is exposed by cutting, across the middle, and turning aside the pronator teres, the flexor carpi radialis, and the palmaris longus, which form a superficial layer in front of it. With a little care the origin of this muscle may be separated as far as the inner condyle of the humerus. In removing the pronator teres, it is necessary to be extremely careful to avoid dividing the radial origin of the flexor sublimis, which forms a very thin prolongation under the pronator. The dissection of the palmar and digital portions of the muscle is the same as that of the flexor profundus.

Divide the anterior annular ligament of the carpus vertically, and remove the palmar fascia: examine the disposition of this structure opposite the heads of the metacarpal bones, and also the relations of the tendons of the flexor sublimis and flexor profundus in the palm of the hand; then dissect the digital sheaths, which must be divided in order to display the singular manner in which the tendons of the flexor sublimis bifurcate and turn round, so as to embrace the corresponding tendons of the flexor profundus.

The *flexor superficialis*, *sublimis*, or *perforatus* (*e e*, *fig.* 118.; *e*, *fig.* 119.) is a broad, flat, thick muscle, divided into four portions below. It *arises* from the internal condyle or epitrochlea of the humerus, and from the ulnar and radius, and is *inserted* into the second phalanges of the fingers. It arises from the epitrochlea by the common tendon, from a rough surface on the fore part of the inner side of the coronoid process of the ulna, and also from about two inches of the radius. This latter origin consists of tendinous fibres attached to that oblique portion of the anterior border of the bone, which extends inwards towards the bicipital tuberosity, and from which arise the supinator brevis above, the flexor longus pollicis below, and the muscle we are now describing in the middle. A great number of fibres also arise from the broad aponeurotic septa which divide this muscle from the flexor carpi ulnaris, and from the other muscles of the superficial layer, viz. the pronator teres, the flexor carpi radialis, and the palmaris longus.

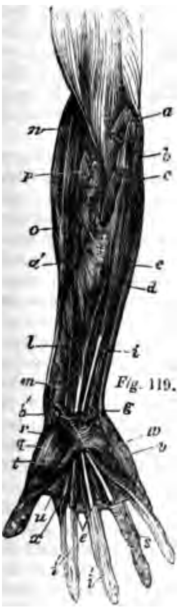


Fig. 119.

From these different origins the fleshy fibres proceed vertically downwards, forming a broad and thick belly, which is almost immediately divided into four portions. These at first are in juxta-position, but soon become arranged in two layers, like the tendons of the extensor communis, viz. one anterior and larger, consisting of the divisions for the median and ring fingers (the latter not being so strong as the former), and another posterior, formed by the divisions for the index and little finger. Each division is, indeed, a small muscle, having its own particular tendon, around which the fleshy fibres are arranged, at first regularly, and afterwards on one side only: they are thus semi-penniform muscles. The two posterior divisions are not so distinct as the anterior, and have a peculiar arrangement: they generally constitute two small digastric muscles; that is to say, a fleshy belly terminates upon a flat tendon, which, becoming enlarged, gives origin in its turn to a new fleshy belly. The four tendons, after emerging from the fleshy

fibres, pass together under the annular ligament (*g*) of the carpus, in conjunction with the median nerve, which lies on their outer side, and is often mistaken for a tendon, and with the tendons of the flexor profundus digitorum and the flexor longus pollicis. This thick bundle of tendons having reached the palm of the hand, is then distributed in a manner to be noticed after the description of the flexor profundus, with the tendons of which those of the flexor sublimis are intimately connected.

Relations. It is covered by the pronator teres, the flexor carpi radialis, the palmaris longus, the flexor carpi ulnaris, and the fascia of the fore-arm; and it covers the flexor profundus digitorum, from which it is separated by the ulnar vessels and nerves: it also covers the median nerve, and the flexor longus pollicis, to which it generally sends a tendinous and fleshy prolongation.

The Flexor Profundus Digitorum.

Dissection. This muscle is exposed by cutting across the flexor sublimis and the flexor carpi ulnaris.

The *flexor profundus* or *perforans* (*i*, *figs.* 119, 120.) is situated under the superficial flexor, which it exceeds in size, but resembles it in being divided below into four portions.

Fig. 120.

Attachments. It *arises* from the upper three fourths of the internal and anterior surfaces of the ulna, from a well-marked cavity situated on the inner side of the coronoid process behind the rough eminence which gives attachment to the internal lateral ligament of the elbow, from the inner two thirds of the interosseous ligament, from that part of the fascia of the fore-arm which covers the inner surface of the ulna, and lastly, by a few fibres, from within and below the bicipital tuberosity of the radius. It is *inserted* into the front of the bases of the last phalanges of the fingers (*i*, *figs.* 119, 120.).

The fleshy fibres arise directly from these numerous origins, and proceed vertically downwards, the internal fibres alone being directed somewhat obliquely forwards and outwards. The belly of the muscle thus formed continues to increase in size, and is then divided into four unequal portions, each constituting a semi-penniform muscle. These four small muscles are in juxta-position, and terminate in as many flat tendons, which occupy the lower two thirds of the anterior surface of the entire muscle, and are remarkable for being divided into very regular and closely united parallel bands of a nearly white colour. The four tendons emerging from the fleshy fibres at various heights, but always above the anterior annular ligament of the carpus, pass under this ligament conjointly with the tendons of the flexor sublimis, the flexor pollicis longus, and the median nerve. In this situation they are placed behind the tendons of the flexor sublimis, which are arranged in two layers, as we have already seen. The tendons of the flexor profundus are always in juxta-position, and moreover are united together by means of dense cellular tissue and tendinous bands passing from one to the other: the fasciculus for the index finger alone remains distinct; and therefore the flexion of this finger is almost as independent of that of the others as its extension, for which latter movement it receives a special muscle. Immediately below the annular ligament the tendons separate from each other; the two anterior tendons of the flexor sublimis no longer cover the two posterior, but all four become situated in front of the corresponding tendons of the flexor profundus, and arrive together at the metacarpo-phalangal articulations: here they are received, at first, into a very strong fibrous sheath,

resulting from the division of the palmar fascia, and afterwards into another sheath (*s*, *figs.* 118, 119.), which converts the groove in front of the phalanges into a canal. If we divide any of these digital sheaths, we find the tendon of the superficial flexor becoming flattened and hollowed underneath, as it were, into a groove, which is exactly moulded upon the tendon of the deep flexor. About the middle of the first phalanx the tendon of the sublimis (*e*, *fig.* 119.) bifurcates, and gives passage to that of the profundus, which it embraces by turning round it like the thread of a screw, and becoming posterior instead of anterior, as it was before. The two halves of the tendon then reunite to form a groove having its concavity directed forwards, and again separate to be inserted into the rough edge of the groove on the second phalanx. The tendon of the flexor profundus (*i' i'*, *figs.* 119, 120.), on the contrary, passes directly through the sheath formed by that of the flexor sublimis, and is inserted into the third phalanx. The tendons of the flexor profundus, moreover, present in their whole course, very slightly apparent traces of division. From the relation of the tendons of the two flexors to each other, the superficial muscle has been called the *perforatus*, and the deep one the *perforans*.

Relations. These should be examined in the fore-arm, in the palm of the hand, and along the fingers.

In the *fore-arm* the flexor profundus is covered by the flexor sublimis, from which it is separated by an incomplete tendinous septum, and by the median nerve. It covers the ulna, the interosseous ligament, and the pronator quadratus; it corresponds within to the flexor carpi ulnaris, and without to the flexor longus pollicis. The ulnar vessels and nerves are, at first, situated between this muscle and the flexor sublimis, and afterwards separate it from the flexor carpi ulnaris.

In the *palm* its tendons are subjacent to those of the flexor sublimis, and cover the interosseous muscles and the adductor pollicis. The lumbricales muscles take their origin from them.

Along the *fingers* its tendons are in relation behind with the grooves of the phalanges, and with the metacarpo-phalangal and phalangal articulations, and, in front, with the tendons of the sublimis, and the fibrous sheaths of the fingers.

Action of the two flexors. These muscles flex the third phalanx upon the second, the second on the first, this again upon the corresponding metacarpal bone, and lastly, the hand upon the fore-arm. The flexor sublimis has no action upon the third phalanges. Its origin from the internal condyle of the humerus enables it to act upon the fore-arm and to assist in flexing it upon the arm. It is scarcely necessary to say that the bifurcation of the tendons of the flexor sublimis is intended to afford a sheath to, and bind down, those of the flexor profundus. The flexor profundus flexes the third phalanx upon the second, the second upon the first, the first upon the corresponding metacarpal bone, and, lastly, the hand upon the fore-arm.

The Lumbricales.

The *lumbricales* (*x*, *figs.* 119, 120.) are small fleshy tongues which may be regarded as accessories of the flexor profundus. They are four in number, distinguished as the *first*, *second*, &c. counting from without inwards. They extend from the tendons of the flexor profundus to the first phalanges of three or four fingers. They *arise* from the tendons after these have passed through the annular ligament; the first and the second, in front of the tendons for the index and middle fingers; the third, in the interval between those for the middle and ring fingers; and the fourth, in the interval between those for the ring and little fingers. From these origins they proceed, those near the median line vertically, and those at either side obliquely downwards, to the outer side of the metacarpo-phalangal articulations of the corresponding fingers, where they terminate by a broad tendinous expansion *inserted* into the edges of the extensor tendons, and completing the sheath which those tendons form on the

back of the first phalanges. The tendon of the third lumbricalis appears to me to be almost always inserted, not into the outer side of the ring finger, but into the inner side of the middle finger; an arrangement that cannot well be accounted for. It is not uncommon to find this third lumbricalis bifurcated, and attached not only to the inner side of the middle, but to the outer side of the ring finger.

Relations. They are placed between and upon the tendons of the flexor profundus, and have, therefore, the same relations as those tendons in the palm of the hand; they are also in relation with the sides of the metacarpo-phalangal articulations, and the tendons of the interosseous muscles

Action. It is difficult to determine their actions precisely. Vesalius has described them as adductors, and Spigelius as flexors. I agree with Riolanus in regarding them as specially intended to keep the extensor tendons closely applied to the phalanges, and to serve instead of a proper sheath. They are of use also in binding together the extensor and flexor tendons, and preventing the displacement of either.

The Flexor Longus Pollicis.

Dissection. The same as that of the flexor profundus.

The *flexor longus pollicis* (*l, fig.* 119, 120.) is situated upon the same plane as the flexor profundus digitorum, of which it may be considered a division; it is thick, elongated, and penniform.

Attachments. It *arises* from the upper three-fourths of the radius, from the contiguous portion of the interosseous ligament, from the anterior border of the radius, and not unfrequently by a prolongation, tendinous at its extremities and fleshy in the middle, from the flexor sublimis digitorum. It is *inserted* into the upper end of the second phalanx of the thumb. The fleshy fibres arise directly from these origins, pass vertically downwards, and are attached to the posterior surface of a flat tendon, which forms a continuation of the series of tendons of the flexor profundus on the outside, and like them is divided into bands. The fleshy fibres accompany the tendon as far as the anterior annular ligament of the carpus; it then passes beneath this ligament, is reflected over the inside of the trapezium, and proceeds obliquely outwards along the first metacarpal bone. When it reaches the metacarpo-phalangal articulation of the thumb, it is received in an osteo-fibrous sheath, resembling in every respect that of the tendons of the other fingers, and, like them, is inserted in front of the upper extremity of the ungual phalanx of its corresponding finger (*l, fig.* 120.).

Relations. It is covered by the flexor sublimis, the flexor carpi radialis, the supinator longus, and the radial artery; it covers the radius and the interosseous ligament, from which it is separated above by the interosseous vessels and nerves, and below by the pronator quadratus. Its tendon is the most external of those which pass under the anterior annular ligament of the carpus, after leaving which it is received into a deep muscular groove formed by the muscles of the ball of the thumb, and is ultimately enclosed in its own osteo-fibrous sheath.

Action. It flexes the last phalanx of the thumb upon the first, this upon the first metacarpal bone, and then the hand upon the fore-arm. In order to understand its action precisely, we must suppose the muscular force to be concentrated upon the upper end of the reflected portion; it is then easy to see that it draws the phalanges inwards, while flexing them. It is therefore an opponens muscle.

The Pronator Quadratus.

Dissection. Cut across all the tendons occupying the lower part of the anterior region of the fore-arm, and this muscle will be exposed.

This small muscle (le petit pronateur, *Bichat, m, figs.* 119, 120.) is situated at the lower part of the anterior region of the fore-arm, and forms the deepest layer of this region. It is regularly quadrilateral, and thicker than at first sight it appears to be.

Attachments. It *arises* from the lower fourth of the internal border of the ulna, which is directed so decidedly backwards inferiorly, that the muscle is rolled round the bone; also from an aponeurotic layer much thicker below than above, directed obliquely upwards and outwards, and occupying the inner third of the muscle, upon which it terminates in a number of elegant intersections; lastly, from all that portion of the anterior surface of the ulna, upon which it lies. From these origins the fibres proceed horizontally outwards (le pronateur transverse, *Winslow*), becoming longer as they are more superficial, to the lower fourth of the external border, anterior surface, and internal border of the radius.

Relations. It is covered by the flexor profundus digitorum, the flexor longus pollicis, the flexor carpi radialis, and the radial and ulnar arteries, and it partially covers the two bones of the fore-arm and the interosseous ligament.

Action. The pronator quadratus tends to approximate the two bones of the fore-arm; but as it is rolled around the ulna, which is immoveable, it causes the radius to turn upon that bone, and is therefore a pronator. Its action in much more energetic than would at first sight appear: this depends on the number of its fleshy fibres, which are arranged in several layers, the most superficial being the longest.

The Muscles of the External Region of the Fore-arm.

The muscles of this region are, the supinator longus, the extensores carpi radiales, longior and brevior, and the supinator brevis.

The Supinator Longus.

Dissection. The brachial portion of this muscle is exposed in the dissection of the brachialis anticus and the triceps, and the portion situated in the fore-arm, by removing the fascia from the outer and anterior aspect of the muscles of this region.

The *supinator longus* (*f, figs.* 118. 121.), which is the most superficial muscle of the external and anterior aspect of the fore-arm, belongs both to the arm and the fore-arm (brachio-radialis, *Sœmmering*), and constitutes in a great measure the oblique ridge forming the external boundary of the bend of the elbow. It is a long flat muscle, fleshy in its upper two-thirds, and tendinous in its lower third.

Attachments. It *arises* from the outer border of the humerus, and from the external inter-muscular septum of the arm; the extent of its humeral attachment varies from the lower fourth to the lower third of that bone, and is limited above by the groove for the musculo-spiral nerve. It is *inserted* into the base of the styloid process of the radius. The fleshy fibres proceed from their origins downwards, forwards, and a little inwards, to form a fleshy belly, which is flattened from *without inwards*, and is applied to the brachialis anticus. After reaching the lower end of the humerus, the fleshy belly becomes flattened from *before backwards*, and passes vertically downwards. At first it is thick, but, during its progess, it expands and becomes thin, until its fibres terminate successively upon the anterior surface of an aponeurosis, which becomes entirely free from fleshy fibres above the middle of the fore-arm, and is gradually contracted into a flat tendon that is inserted into the styloid process of the radius.

Relations. It is covered by the fasciæ of the arm and fore-arm: in the arm it is enclosed in the same sheath with the brachialis anticus, from which it is separated by the radial or musculo-spiral nerve; in the fore-arm it has a sheath proper to itself: it is in relation with the brachialis anticus, which is at first within and afterwards behind it; then with the extensor carpi radialis longior,

the tendon of the biceps, the supinator brevis, the pronator teres, the flexor carpi radialis, the flexor digitorum sublimis, the flexor longus pollicis, the radial artery and veins, and the radial nerve. Its inner border limits the bend of the elbow on the outside: the radial artery emerges from beneath this border, and then lies parallel to it. Its outer border is separated from the extensor carpi radialis longior by cellular tissue, and inferiorly is in contact with the dorsal branch of the radial nerve, which, at first, was situated beneath it. The most important of all these relations is that with the radial artery, of which the long supinator may be considered the satellite muscle, and might be designated the *muscle of the radial artery.*

Action. It might be asked, Why does the supinator longus form an exception to the general rule, in being inserted into the lower end of the lever which it is intended to move? for while the fore-arm is in a state of supination, the axis of the muscle is vertical, and its action appears limited to that of flexing the fore-arm; but if the limb be pronated, the direction of the muscle becomes oblique from without inwards, and, therefore, supination is the result of its contraction. After this effect has been produced, if the muscle still continues to act, the fore-arm is flexed upon the arm. It is needless to state that the distance of its insertion from the fulcrum gives the muscle great power, notwithstanding its disadvantageous angle of incidence.

The Extensor Carpi Radialis Longior.

Dissection. This muscle, as well as the succeeding one, will be exposed at the same time as the supinator longus, beneath which it is placed. The lower end of its tendon occupies the dorsum of the wrist, and should also be exposed.

The *extensor carpi radialis longior* (le premier ou long radial externe; radialis externus longior, *Albinus, n, figs.* 119. 121.) is situated on the external and posterior aspect of the fore-arm, below the supinator longus, of which it seems to be a continuation at its origin from the humerus: like that muscle, it is flattened from within outwards in the arm, and from before backwards in the fore-arm: it is fleshy in its upper third, and tendinous in its lower two-thirds.

Attachments. It *arises* from the rough triangular impression terminating the external border of the humerus, from the external intermuscular septum and from the anterior surface of the common tendon. It is *inserted* into the back of the upper end of the second metacarpal bone. The fleshy fibres arising directly from the parts mentioned constitute a bundle, at first flattened on the sides, and forming a continuation of the supinator longus, from which it is often difficult to separate it: it afterwards becomes flattened from before backwards. The fibres pass vertically downwards, and are attached to the anterior surface of a tendon a little beyond the upper third of the fore-arm. The tendon then becomes narrower and thicker, proceeds along the outer border of the radius, passes under the tendons of the abductor longus and extensor brevis pollicis, which cross it obliquely, and turns a little outwards and then backwards to arrive at a groove common to it and the extensor carpi radialis brevior; it is then crossed at an acute angle by the tendon of the extensor longus pollicis, and is finally inserted by an expanded termination into the second metacarpal bone (*n', fig.* 121.).

Relations. It is covered by the supinator longus and the fascia of the fore-arm; on the outside of the fore-arm it is covered and crossed obliquely by the abductor longus and extensor brevis pollicis, and in the wrist by the tendon of the extensor longus pollicis. It covers the elbow joint, the extensor carpi radialis brevior, and the back of the wrist joint.

The Extensor Carpi Radialis Brevior.

The *extensor carpi radialis brevior* (le second ou court radial externe; radialis externus brevior, *Albinus, o, figs.* 119. 121, 122.) is thicker but shorter than the preceding, below which it is placed. It *arises* from the external condyle

r epicondyle of the humerus, by a tendon common to it and the extensor ıuscles of the fingers; also from a very strong aponeurosis situated upon its ›sterior surface; and from another tendinous septum which divides it from ıe extensor communis digitorum. It is *inserted* into the back part of the upper ıd of the third metacarpal bone. The fleshy fibres, thus arising from the exrnal condyle by means of an aponeurotic pyramid, are attached to the posrior surface of a tendon which becomes gradually narrower and thicker as it ›ceives them. The fibres themselves terminate about the middle of the fore'm, and then the flat tendon passes backwards into the same groove on the ıdius as that of the last-named muscle, the two tendons being retained in by the same fibrous sheath, and lubricated by the same synovial membranes, ıt separated from each other by a small vertical ridge of bone. After leaving ıe common sheath, the tendon of the short separates from that of the long ıdial extensor, passes still more posteriorly, and is inserted into the third ıetacarpal bone (*o'*, *figs.* 121, 122.).

Relations. It is covered by the preceding muscle, and like it is crossed obquely on the outside by the long abductor, the short and then the long ex›nsor muscles of the thumb: it covers the external surface of the radius, from 'hich it is separated by the supinator brevis above, and the pronator teres in ıe middle. Its tendon covers and protects the back of the wrist. In con›quence of the different length of their fleshy fibres, the supinator longus and ıe two radial extensors of the carpus are arranged one above the other, the ighest being the supinator longus, and the lowest the extensor carpi radialis revior.

Action of the two radial extensors. These two muscles, which from their in›rtions might be called the *posterior* radials, extend the second row of the ırpus upon the first, and this upon the fore-arm; they are also abductors of ıe hand, for they incline it towards the radial side of the fore-arm. The xtensor carpi radialis longior being attached to the humerus, can assist in exing the fore-arm.

The Supinator Brevis.

Dissection. Pronate the fore-arm forcibly. In order to expose this muscle ompletely, divide the two radial extensors of the carpus, and even some of the ıuscles of the superficial layer on the back of the fore-arm.

The *supinator brevis* (*p*, *figs.* 119, 120. 122.) is a broad muscle curved into he form of a hollow cylinder, and rolled round the upper third of the radius: t forms by itself the deep layer of the external region of the fore-arm.

Attachments. It *arises* from the external lateral ligament of the elbow, with vhich it is blended, and by this means from the external condyle; from the ınnular ligament of the radius; from the external border of the ulna, which is rovided with a projecting ridge for this purpose; from *a deep triangular exca›ation, in front of this ridge, and below the lesser sigmoid cavity of the ulna*; and, astly, from the deep surface of an expansion of its tendon of origin and the ›xternal lateral ligament, which covers the greater part of the muscle. From hese different origins (*fig.* 122.) the fleshy fibres pass round the radius, into he posterior, external, and anterior surfaces of which bone they are inserted. ›mbracing in front the bicipital tubercle and the tendon of the biceps (*figs.* 119, 120.). I have seen a fleshy prolongation of this muscle, covering the an›erior half of the annular ligament of the radius, of which it might be regarded ın extensor.

Relations. The supinator brevis is covered by the radial extensors, the supinator longus, the pronator teres, the extensor communis digitorum, the extensor digiti minimi, the extensor carpi ulnaris, the anconeus, and the radial artery and vein: it covers the upper third of the radius, and also its annular ligament, the elbow joint, and the interosseous ligament. It is perforated by the deep branch of the radial nerve, which is distributed to all the muscles on the back of the fore-arm.

Action. No muscle in the body is so completely rolled around the lever that it is intended to move, for it forms five sixths of a cylinder; it is therefore the chief agent in supination, and the supinator longus can only be regarded as an accessory.

Muscles of the Posterior Region of the Fore-arm.

The muscles of the posterior region of the fore-arm constitute two very distinct layers, one *superficial*, comprising the extensor communis digitorum, the extensor digiti minimi, and the extensor carpi ulnaris; the other *deep*, comprising the abductor pollicis longus, the extensor brevis and extensor longus pollicis, and the extensor indicis.

Muscles of the Superficial Layer.

One mode of *dissection* is common to all these muscles. Make a circular incision through the skin at the lower part of the arm; pronate the arm, and make a perpendicular incision from the external condyle of the humerus to the third metacarpal bone, entirely dividing the sub-cutaneous cellular tissue down to the fascia; remove this fascia by careful dissection, except where it is very adherent. Trace the tendons of the extensor muscles along the back of the fingers.

The Extensor Communis Digitorum.

The *extensor communis digitorum* (*b*, *fig.* 121.), situated at the back of the fore-arm, simple above and divided into four portions below, *arises* from the external condyle of the humerus, and is *inserted* into the second and third phalanges of the four fingers. Its origin consists of a tendon common to it, and to the extensor carpi radialis brevior, extensor digiti minimi, and extensor carpi ulnaris. This tendon consists of a four-sided pyramid, and is formed by the fascia of the fore-arm, by a lamina separating this muscle from the extensor carpi radialis longior, by another lamina separating it from the extensor digiti minimi and the extensor carpi ulnaris, and lastly by another situated between it and the supinator brevis. The fleshy fibres arising from the interior of this pyramid form at first a thin, but afterwards a much larger muscle, which becomes flattened from before backwards, and soon divides into four fasciculi. The two middle fasciculi, intended for the middle and the ring fingers, are stronger than those destined for the index and little fingers, *i. e.* the two extreme fasciculi, which, lower down, become placed in front of the middle fasciculi. In this manner they all pass under the dorsal ligament (*r*, *fig.* 121.) of the carpus in a proper sheath. After leaving this sheath, in which they are provided with a synovial capsule*, extending both above and below the dorsal ligament, the four tendons become situated on the same plane and diverge from each other; the two middle tendons proceed along the backs of the corresponding metacarpal bones; the external and internal tendons (*b′ b′*, *fig.* 121.) correspond to the interosseous spaces, which they cross obliquely in order to assume a position behind the heads of the metacarpal bones to which they belong. Having reached the

Fig. 121.

* See note, p. 389.

›o-phalangal articulations, the tendons become narrower and thickened, › off on each side a fibrous expansion, attached to the sides of the ıey then enlarge again so as to cover the dorsal surface of the first ›s, receive and are re-inforced by the tendons of the lumbricales, and the articulation of the first with the second phalanx, they divide into ›rtions, one median, which is implanted upon the upper end of the ›halanx, and two lateral, which pass along the sides of the second pha- proach each other at the lower half of the dorsal surface of the second unite by their neighbouring edges, and are inserted into the upper ıe third phalanx. Opposite the metacarpal bones they sometimes split › or three small juxta-posed tendons, and at the lower end of these ıe tendons for the little, ring, and middle fingers communicate with er by expansions of variable size, and sometimes by a true bifurcation 121.). The tendon for the index finger is alone free. The communica- ıe tendon of the little with that of the ring finger takes place opposite ıcarpo-phalangal articulation, by means of a transverse band, which projection under the skin. Lastly, we not uncommonly see a tendinous tion arising from the anterior surface of these tendons, and inserted upper end of the first phalanx.

ons. The extensor communis digitorum is covered by the fascia of arm, from which a great number of its fibres arise superiorly, by the gament of the carpus and the dorsal fascia of the metacarpus, which it from the skin: it covers the supinator brevis, the three long of the thumb, the extensor proprius indicis, the lower radio-cubital ion, the carpus, the metacarpus, and the fingers.

ı. This muscle extends the third phalanx upon the second, the se- ›n the first, the first upon the corresponding metacarpal bone, then us, and lastly the radio-cubital articulation. It is necessary for me to the independence of the muscular fasciculi proceeding to each finger: eculiar to man, and is much more remarkable in some individuals others. By continual exercise, the faculty of extending one finger the others may be acquired. The tendon for the index is generally › one not united to the others, and therefore the movements of this ›e by far the most independent.

The Extensor Digiti Minimi.

is a very slender muscle (extensor proprius auricularis, *Albinus*, *c*,) placed on the inner side of the common extensor, to which it appears appendix. It is difficult to trace its origin as far as the common tendon, ich it is connected only by an aponeurotic prolongation. Its fleshy *ise* from this prolongation, and from a fibrous pyramid which separates the muscles of the deep layer, from the extensor communis digitorum ly, and internally from the extensor carpi ulnaris, and is completed ıally by the fascia of the fore-arm. The fibres constitute a small fu- eshy belly, which accompanies the tendon (at least on one side), as ıe head of the ulna; there the tendon enters a special fibrous sheath behind the head of that bone; it is then reflected inwards to the fifth pal bone, behind which it is retained in a thinner sheath, which, like eding, is lined by a synovial membrane.* The tendon then splits into ds, of which the external (or radial) receives the inner bifurcation xtensor communis. The three tendinous prolongations becoming nvelop, as in a sheath, the dorsal aspect of the first phalanx of this having reached the articulation of the first with the second phalanx, ride into three portions, which are attached precisely in the same as the tendons of the extensor communis.

ı. As its name indicates, this muscle extends the little finger. It

* See note, p. 389

might at first sight be imagined that this finger might be moved independently, since it receives a separate muscle; but the connection of its tendon with that of the extensor communis, renders any such independent action as difficult as in the other fingers, and much more so than in the index finger.

The Extensor Carpi Ulnaris.

The *extensor carpi ulnaris* (*e*, *fig.* 121.), the most superficial and the most internal * of the muscles on the back of the fore-arm, *arises* from the external tuberosity of the humerus; from the posterior surface of the ulna, which is a little excavated for this purpose; from the middle third of the posterior border of that bone; and from the anterior surface of an aponeurosis covering the muscle behind. It is *inserted* behind the upper end of the fifth metacarpal bone. Its origin is effected by means of a fibrous pyramid, the apex of which is attached to the outer tuberosity of the humerus. From the interior of this pyramid, and from the other origins above-mentioned, the fleshy fibres proceed to a tendon, which by a very uncommon arrangement extends through the substance of the muscle, even from its superior attachment, without commencing in the form of an aponeurosis. At the lower third of the fore-arm, this tendon appears on the posterior border of the then semi-penniform muscle, and continues to receive fleshy fibres on its anterior edge until it enters the groove intended for it on the ulna. This oblique groove is continued as far as the insertion of the tendon into the metacarpal bone, by means of a long fibrous sheath, and is lined throughout by a synovial membrane.

Relations. The extensor carpi ulnaris is covered by the fascia of the fore-arm: it covers the ulna, the supinator brevis, and the muscles of the deep layer.

Fig. 122.

Action. It extends the second row of the carpus upon the first, and this upon the fore-arm. It is at the same time an adductor of the hand, which it inclines towards the ulnar border of the fore-arm.

The Anconeus.

The *anconeus* (brevis anconeus, *Eustachius;* le petit anconé, *Winslow*, *g*, *figs.* 121, 122.) is a short triangular muscle, so named from its situation (ἀγκὼν, the prominence of the elbow). It appears to be a continuation of the external portion of the triceps, from which it is only separated by a very slight cellular interval.

Attachments. It *arises* from the back part of the outer tuberosity of the humerus, and is *inserted* into the outer side of the olecranon, and a triangular surface bounded internally by the posterior border of the ulna. Its origin from the condyle consists of a tendon quite distinct from that common to the muscles on the back part of the fore-arm. This tendon splits into two diverging bands. The fleshy fibres arising from these proceed inwards, the upper horizontally, the lower obliquely downwards, and are inserted directly into the outer side of the olecranon so as to be continuous with the triceps, and into the surface of the ulna.

Relations. It is covered by a prolongation from the fascia of the triceps, and it covers the radio-humeral ar-

* It is needless to remark that this internal situation presupposes the supination of the fore-arm. In pronation this muscle may be correctly termed ulnaris externus, and le cubital externe, according to *Albinus* and *Winslow*.

ticulation, the annular ligament of the radius, the ulna, and a small portion of the supinator brevis.

Action. It extends the fore-arm upon the arm, and *vice versâ*; from its oblique direction, it can also rotate it inwards.

Muscles of the Deep Layer.

Dissection. This is the same for all the muscles of the deep layer of the fore-arm, and consists in removing the muscles of the superficial layer, especially the extensor communis digitorum and the extensor digiti minimi.

The Abductor Longus Pollicis.

The *abductor longus pollicis* (extensor ossis metacarpi pollicis, *i*, *figs.* 121, 122.) is the broadest, thickest, and most external muscle of the deep layer (le grand abducteur, *Bichat*).

Attachments. It *arises* from the ulna below the origin of the supinator brevis, from the interosseous ligament, from the radius, and from a tendinous septum between it and the extensor longus pollicis. It is *inserted* into the upper end of the first metacarpal bone. From the above-mentioned origins the fleshy fibres proceed obliquely downwards and outwards, constitute a flattened fusiform belly, and are successively attached to the posterior surface of an aponeurosis, which becomes condensed into a flat tendon; this tendon turns round the radius, crossing over the radial extensors of the carpus, and at the same time ceasing to receive any fleshy fibres; it is then received into the outer groove on the lower end of the radius, conjointly with the tendon of the extensor brevis pollicis, a small fibrous septum intervening between them, and finally is inserted into the first metacarpal bone. This tendon is almost always divided longitudinally into two equal parts, and not unfrequently the division extends up to the fleshy portion. Of these two divisions one is inserted into the first metacarpal bone, the other furnishes attachments to the abductor brevis pollicis.

Relations. It is covered by the extensor communis digitorum and extensor digiti minimi: it lies immediately under the fascia, from the outer side of the radius to its termination. It covers the interosseous ligament, the radius, the tendons of the radial extensors of the carpus, and the outer side of the wrist joint, where it may be easily distinguished under the skin.

Action. It extends and abducts the first metacarpal bone: for a long time it was called the extensor of the thumb; but its chief use is, as Albinus first remarked, in abduction. Winslow observes that, from its obliquity, it can act as a supinator; lastly, it assists in extending the hand.

The Extensor Brevis Pollicis.

This muscle (extensor primi internodii pollicis, *l*, *figs.* 121, 122.) is situated internally to the preceding, which it exactly resembles in figure and direction, and with which it was for a long time confounded (partie du premier extenseur du pouce, *Winslow*). It is, however, shorter and more slender (petit extenseur du pouce, *Bichat*).

It *arises* from the radius, occasionally from the ulna, and from the interosseous ligament; and is *inserted* into the upper end of the first phalanx of the thumb. Its origin consists of short tendinous fibres, the fleshy fibres proceeding from which constitute a slender fasciculus, having a similar arrangement to that of the preceding muscle; its tendon is received into the same fibrous sheath, but is divided from the other by a small septum, and passes on to be inserted into the first phalanx.

Relations. The same as those of the abductor longus.

Action. It extends the first phalanx upon the first metacarpal bone, and then becomes an abductor and extensor of the metacarpal bone of the thumb.

The Extensor Longus Pollicis.

This muscle (extensor secundi internodii pollicis, *m*, *figs.* 121, 122.) is much larger than the extensor brevis, within and parallel to which it is situated. It *arises* from a considerable extent of the ulna, from the interosseous ligament, and from the tendinous septa dividing it from the extensor carpi ulnaris, and the extensor proprius indicis: it is *inserted* into the upper end of the second phalanx of the thumb. The fleshy fibres form a flat fusiform bundle, directed obliquely like the preceding muscle; they terminate in succession around a tendon, which emerges from them at the carpal extremity of the ulna, enters a special osteo-fibrous sheath, and crosses obliquely over the tendons of the two radial extensors, being separated from the tendons of the abductor longus and extensor brevis pollicis by an interval which may be readily distinguished through the integuments, and gives rise to the hollow on the outer side of the wrist, commonly called the salt-cellar. The tendon next crosses obliquely over the first interosseous space, gains the inner edge of the first metacarpal bone, and then that of the first phalanx, upon which it is expanded, and proceeds to be inserted into the second or ungual phalanx of the thumb.

Relations. Its general relations are the same as those of the preceding muscle.

Action. Its uses are also the same; but it acts in a special manner upon the second phalanx of the thumb, which it extends upon the first before exerting any influence upon this last-mentioned bone. It has less power in abduction than the preceding muscles.

The Extensor Proprius Indicis.

This is an elongated fusiform muscle (indicator, *Albinus*, *r*, *fig.* 122.) like the preceding, below and parallel to which it is situated. It *arises* from the ulna, the interosseous ligament, and a septum intervening between it and the extensor longus pollicis: it is *inserted* into the two last phalanges of the index finger. The fleshy fibres proceed obliquely from their origins and terminate around a tendon, which they accompany as far as the sheath of the extensor communis digitorum: into this sheath the tendon enters, and, having escaped from it, crosses obliquely over the carpus and the second interosseous space, becomes situated on the inside of the tendon given off to the index finger by the extensor communis, unites intimately with that tendon opposite the lower end of the metacarpus, and terminates with it in the manner already indicated. Its *relations* are the same as those of the preceding muscles.

Action. It enables the index finger to be extended independently of the others, and hence, without doubt, arises the particular use of that finger. I should add, that the union of its tendon with the one furnished by the common extensor is so intimate, that its independence of action would have been much less had not the fleshy fasciculus of the common extensor destined for it been itself almost isolated.

MUSCLES OF THE HAND.

The abductor brevis pollicis. — Opponens pollicis. — Flexor brevis pollicis. — Adductor pollicis. — Palmaris brevis. — Abductor digiti minimi. — Flexor brevis digiti minimi. — Opponens digiti minimi. — The interosseous muscles, dorsal and palmar.

THE muscles of the hand occupy the entire palmar region. They are divided into those situated on the outer side, viz. the muscles of the *thenar* eminence, or ball of the thumb; those on the inner side, viz. the muscles of the *hypothenar* eminence, or of the little finger; and those which occupy the interosseous spaces.

All the muscles of the thenar eminence belong to the thumb; they are, in the order of their superposition, the abductor brevis, the opponens, the flexor brevis, and the adductor pollicis. Those of the hypothenar eminence all belong

to the little finger, and are the abductor, the flexor brevis, and the opponens. The palmaris brevis may be included in this region.

The interosseous muscles are seven in number — four dorsal and three palmar. The lumbricales, which belong to this region, have been already described with the tendons of the flexors of the fingers.

Muscles of the Thenar Eminence, or Muscles belonging to the Thumb.

I divide these into three muscles inserted into the outer side of the first phalanx of the thumb, or into the first metacarpal bone, and a single muscle inserted into the inner side. The former are the abductor brevis, the opponens, and the flexor brevis; the latter consists of the adductor, in which I include a part of the flexor brevis of authors generally.

Muscles inserted into the Outer Side of the First Phalanx of the Thumb, or into the First Metacarpal Bone.

Dissection. Make an oblique incision from the middle of the annular ligament of the carpus to the outer side of the first phalanx of the thumb, and a circular incision round the wrist; detach the flaps, raise the external and middle palmar fasciæ, and then cautiously separate the muscles of this region, which are recognised by the following characters.

The Abductor Brevis Pollicis.

This is the most superficial of the muscles constituting the ball of the thumb (*q*, *fig.* 119.). It *arises* by tendinous and fleshy fibres from the os scaphoides, from the upper, anterior, and external part of the anterior annular ligament of the carpus, and almost always from an expansion of the tendon of the abductor longus pollicis. It is a small, thin, flat muscle, passing outwards and downwards, and *inserted* by a flat tendon into the outer side of the first phalanx of the thumb. A very narrow cellular line separates it on the inside from the flexor brevis, which is situated on the same plane. It is covered by the external palmar fascia, and it covers the opponens muscle, from which it is distinguished by the direction of its fibres, and by a thin intervening aponeurosis.

Action. It draws the thumb forwards and inwards, and therefore might be termed the superficial opponens. From its attachments it might be called *scaphoido-phalangal.*

The Opponens Pollicis.

The *opponens pollicis* (*r*, *figs.* 119, 120.), a small triangular muscle, *arises* from the trapezium, and the anterior and external part of the anterior annular ligament of the carpus, in front of the sheath of the flexor carpi radialis. From these origins, which are partly fleshy and partly tendinous, the fleshy fibres radiate downwards and outwards, the highest being the shortest and the most horizontal. They are *inserted* into the entire length of the outer border of the first metacarpal bone.

This muscle is covered by the abductor brevis, which projects a little beyond it on the outside, and from which it is separated by a more or less distinct aponeurosis. It covers the first metacarpal bone and its articulation with the trapezium.

Action. It draws the first metacarpal bone inwards and forwards, thus opposing it to the others, as its name indicates. From its attachments it may be called *trapezio-metacarpal.*

The Flexor Brevis Pollicis.

It is difficult to point out the limits of this muscle, or rather they have hitherto been quite arbitrary. Its inferior attachment has been usually divided between the external and the internal sesamoid bones (Boyer, *Traité d'Anatomie* tom. ii. p. 307.; Bichat, *Anatomie Déscriptive*, tom. ii. p. 272.); but we shall consider that portion only which is attached to the external sesamoid bone, as belonging to this muscle, referring the entire fleshy mass that is inserted into the internal sesamoid bone to the adductor pollicis.*

This division is moreover established by the tendon (*l*, *fig.* 120.) of the flexor longus pollicis. Proceeding then from below upwards, in the dissection of the flexor brevis (*t*, *figs.* 119, 120.), we shall see that it is triangular, much larger than the preceding two muscles, bifid above, and channelled in front. It arises by tendinous and fleshy fibres from a process on the trapezium, from the lower edge of the annular ligament, from all the reflected portion of that ligament forming the sheath of the flexor carpi radialis and extending as far as the os magnum, and from the os magnum itself by a portion which is usually distinct. From these different origins the fleshy fibres proceed downwards and outwards, the internal being the most oblique; and, converging so as to form a thick fasciculus, are inserted, through the medium of the external sesamoid bone, into the first phalanx.

Relations. It is covered by the external palmar fascia, which is prolonged in front of it: it covers the tendon of the flexor longus pollicis, and more internally those of the common flexor. It also covers a small portion of the outer border of the adductor pollicis, and the tendon of the flexor carpi radialis. Its outer border, or rather side, is in relation with the short abductor, from which it is easily separated, and with the opponens, sometimes being continuous with it. Its inner border is distinct from the adductor below, but is confounded with it at its origin. Its tendon of insertion into the phalanx is covered by that of the short abductor, which lies externally to it. From its attachments it might be called *trapezio-phalangal*, and, from its uses and position, the *opponens internus*.

Action. It is evidently not a flexor pollicis, but, like the preceding muscles, it draws the thumb forwards and inwards; and it acts more decidedly in producing the latter effect, because it is inserted in a more favourable manner than the other muscles. This, therefore, is also an opponens muscle.

Muscle inserted into the Inner Side of the First Phalanx of the Thumb.

The Adductor Pollicis.

This is the largest of all the muscles of the thumb (*u*, *figs.* 119, 120.); it is very irregularly triangular; and *arises* from the entire extent of the anterior border of the third metacarpal bone, from the anterior surface of the os magnum, from the anterior and upper part of the trapezoides, from the anterior part of the trapezium by a tendinous and fleshy fasciculus, and from the palmar interosseous fascia near the third metacarpal bone. From these different origins the fleshy fibres proceed, the lower horizontally, the rest more

* The arrangement I have adopted is founded upon the inferior attachments of the muscles; for at their origins they are so blended that their division is more or less arbitrary. I divide the muscular fasciculi connected with the thumb, therefore, into two sets, viz. those proceeding from the carpus to the first metacarpal bone and to the outer side of the first phalanx of the thumb, and those extending from the carpus to the inner side of the same phalanx. The first set, which might be regarded as a single muscle, comprises the abductor brevis, the opponens, and the flexor brevis; the other constitutes the abductor pollicis, which I regard as the first palmar interosseous muscle. The action of the first set is common, viz. to carry the thumb forwards and inwards; they are, therefore, all muscles of opposition (perhaps no muscles are so badly named as those of the thenar eminence); the muscle formed by the second set is really an adductor, as its name implies, and so are all the palmar interossei, among which it should be included.

and more obliquely outwards; they all converge to form a thick fleshy bundle, which is inserted through the medium of the internal sesamoid bone into the first phalanx of the thumb.

Relations. Its inner two thirds are deeply situated, and covered by the tendons of the flexor profundus digitorum, by the lumbricales, and by an aponeurosis, which, becoming continuous with the deep interosseous fascia, constitutes the sheath of the muscle. It is subcutaneous near its lower border. It covers the first two interosseous spaces, from which it is separated by a very strong aponeurosis. It is again subcutaneous behind, also along its lower border, which may be easily felt under the fold of skin, extending from the thumb to the index finger.

Action. It is an adductor; it draws the thumb towards the median line or axis of the hand, represented by the third metacarpal bone.

Muscles of the Hypothenar Eminence, or Muscles belonging to the Little Finger.

These muscles correspond exactly to those of the thumb: the reason that three only are described is, that the one which represents the adductor of the thumb is situated in the fourth interosseous space, and is, therefore, classed with the interosseous muscles, to be hereafter described. All the muscles of the hypothenar eminence are inserted into the inner side of the first phalanx of the little finger, or into the third metacarpal bone. We find also a cutaneous muscle in this region, viz. the palmaris brevis.

The Palmaris Brevis.

This is a very thin square muscle (caro quædam quadrata, *b*, *fig.* 118.) situated in the adipose tissue covering the hypothenar eminence. It *arises* from the anterior annular ligament of the carpus, and the inner edge of the middle palmar fascia, by very distinct tendinous fasciculi, succeeded by equally distinct fleshy bundles, which pass horizontally inwards, and terminate in the skin.

Relations. It is covered by the skin, to which it adheres intimately, espepecially by its inner extremity (le palmaire cutané, *Winslow*); it covers the muscles of the hypothenar eminence and the ulnar artery and nerve, from all of which it is separated by the internal palmar fascia.

Action. It corrugates the skin over the hypothenar eminence.

The Abductor Digiti Minimi.

It *arises* from the pisiform bone, and from an expansion of the flexor carpi ulnaris, by tendinous fibres; these are succeeded by a fusiform fleshy belly (*v*, *fig.* 119.), which passes vertically along the internal (or ulnar) surface of the fifth metacarpal bone, and is inserted by a flat tendon into the inner side of the first phalanx of the little finger.

Relations. It is covered by the external palmar fascia. and covers the opponens digiti minimi.

Action. As its name denotes, it abducts the little finger from the axis of the hand.

The Flexor Brevis Digiti Minimi.

This muscle (*w*, *fig.* 119.) is situated on the outer or radial border of the preceding, from which it is distinguished by *arising* from the unciform bone. The two muscles are separated by the ulnar vessels and nerves, which pass between them in order to penetrate into the deep palmar region. In other respects, as in direction, insertions, and relations, the muscles resemble each other; they have accordingly been described by Chaussier as a single muscle,

under the name of *le carpo-phalangien du petit doigt.* This muscle is often wanting, but the fleshy fibres which usually constitute it are then always found in some measure blended with the other muscles.

Action. It produces slight flexion of the little finger.

The Opponens Digiti Minimi.

This muscle (*y, fig.* 119.) is generally distinct from the preceding, and is the representative of the opponens pollicis. It *arises* from the hooklike process of the unciform bone, and from the contiguous part of the annular ligament: from these points the fibres proceed downwards and inwards (*i. e.* towards the ulnar border of the hand), the highest being the shortest and the most horizontal: they are *inserted* into the whole length of the inner or ulnar margin of the fifth metacarpal bone.

Relations. It is covered by the preceding muscles and by the internal palmar fascia: it covers the fifth metacarpal bone, the corresponding interosseous muscle, and the tendon of the superficial flexor proceeding to the little finger.

Action. It opposes the little finger to the thumb by drawing it forwards and outwards.

The Interosseous Muscles.

Dissection. Remove the tendons of the extensor muscles behind, and those of the flexor muscles in front, together with the lumbricales, preserving at the same time the digital insertions of these small muscles. Dissect and study the deep palmar fascia, a fibrous layer covering the interosseous muscles in the palm of the hand, which sends prolongations between the two kinds of these muscles, and is inserted into the anterior borders of the metacarpal bones, inclosing each interosseous muscle in a proper sheath. After having studied the palmar and dorsal fascia, separate the bones of the metacarpus by tearing their connecting ligaments, and the interossei will then be completely exposed.

The *interossei*, so named from their position, and distinguished from each other by the numerical appellations, first, second, third, &c. are divided into *palmar* (*p p p, fig.* 123.) and *dorsal* (*d d d d*), according as they are situated nearer to the palm or to the back of the hand. They are also distinguished into *adductors* and *abductors* of the fingers.

There are two in each interosseous space, one occupying its dorsal, the other its palmar aspect; and as there are four interosseous spaces, it would seem that there should be eight interosseous muscles· nevertheless seven only are admitted by modern anatomists in consequence of the first palmar interosseous muscle, which belongs to the thumb, being separately described as the adductor pollicis. This separation is founded upon the peculiar arrangement presented by that muscle, which is not attached from the first to the second, but extends from the first to the third metacarpal bone, an important fact, that explains the great extent to which the thumb can be adducted.

A minute description of the interosseous muscles would be both useless and tedious. I shall content myself with pointing out their general conformation, and the law which regulates their arrangement.

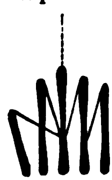
In taking a general view of the interrosseous muscles, they must be considered with regard to the adduction or abduction of the fingers: but these terms must not be understood in reference to the axis of the skeleton, but to the axis of the hand, which is represented by a line passing through the third metacarpal bone and the middle finger. This being admitted, all the dorsal interossei will be found to be abductors, and all the palmar interossei adductors.

Thus, the first dorsal interosseous muscle proceeds from the first and second metacarpal bones to the *outer* or *radial side* of the first phalanx of the index finger: it is therefore an abductor of that finger. The second extends from the second and third metacarpal bones to the *outer* or *radial side* of the first phalanx of the middle finger, and is an abductor of that finger. The third

extends from the third and fourth metacarpal bones to the *inner* or *ulnar side* of the phalanx of the middle fingers, and is also an abductor of the same, because it separates it from the supposed axis of the hand. The fourth extends from the fourth and fifth metacarpal bones to the *inner* or *ulnar side* of the first phalanx of the fourth finger, and it again is an abductor of that finger from the axis of the hand, although, as well as the preceding muscle, it is an adductor as regards the axis of the body. In order to render this view more intelligible, I have been accustomed to represent the five fingers by five lines (see diagram *d*), to prolong the middle line for the axis of the hand, and then to draw other lines (the four fine lines), representing the *axes* of the muscles; the demonstration is thus rendered complete.

d

In the same manner, all the palmar interossei are adductors as regards the axis of the hand. Thus the first, which is represented by the adductor pollicis, and extends from the third metacarpal bone to the *inner* or *ulnar side* of the first phalanx of the thumb, is an adductor as regards the axis of the hand as well as that of the body; the second, extending from the second metacarpal bone to the *inner* or *ulnar side* of the first phalanx of the index finger, is an adductor both as regards the axis of the hand and that of the body; the third, extending from the fourth metacarpal bone to the *outer* or *radial side* of the first phalanx of the ring finger, is an adductor as regards the axis of the hand; and lastly, the fourth, extending from the fifth metacarpal bone to the *outer* or *radial side* of the first phalanx of the little finger, is an adductor as regards the axis of the hand, but an abductor in reference to the axis of the body. A similarly constructed figure, as that employed for the dorsal interossei, will always keep this arrangement in the memory (see diagram *p*; the four fine lines represent the *axes* of the palmar muscles). The general disposition of the interossei may be summed up in the following very simple law:— all the dorsal interossei have their fixed attachments *further* from the axis of the hand than their moveable one; all the palmar interossei have their fixed attachments *nearer* to the axis of the hand than their moveable one.



p

We may now consider the general arrangement of these little muscles.

The Dorsal Interossei.

These are short, prismatic, and triangular muscles (*d* to *d*, *fig.* 123.), extending from the two metacarpal bones, between which they are placed, to the first phalanx and the extensor tendon of one of the corresponding fingers. They *arise* by a double origin, between which the perforating arteries pass. But while one of these origins is limited to the back part of the lateral surface of one of the metacarpal bones, the other occupies the whole length of the corresponding lateral surface of the other metacarpal bone. From this double origin the fleshy fibres pass obliquely forwards round a tendon, which only emerges from them near the metacarpo-phalangal articulation; it then expands, and is inserted partly to the upper end of the first phalanx and partly to the outer edge of the corresponding extensor tendon.

Fig. 123.

Relations. The dorsal interossei correspond behind with the dorsal surface of the hand and the extensor tendons, from which they are separated by a very thin aponeurosis; in front, they are visible in the palm of the hand by the sides of the palmar interossei, and, like the latter, are covered by the muscles and tendons of the palmar region, being separated from those parts by the deep

palmar fascia. A distinct cellular line, or rather an aponeurotic septum, intervenes between one of their lateral surfaces and the corresponding palmar interosseous muscle; the other lateral surface is in relation through its entire length with the metacarpal bone on which it is implanted.

Action. These muscles are evidently abductors of the first phalanges of the fingers, the axis of the hand being taken as the point of departure. Their insertion into the extensor tendons explains why previous extension of the fingers is necessary to the movement of abduction.

The *first dorsal interosseous muscle* merits a special description. It is larger than the others, on account of the greater size of the space occupied by it; it is flat and triangular, and *arises* by two origins, separated not by a perforating branch but by the radial artery itself. A fibrous arch completes the half ring formed by the interval between the first two metacarpal bones for the passage of this artery. The external head of the muscle arises from the upper half of the inner border of the first metacarpal bone; the internal from the entire length of the external surface of the second metacarpal bone, and from the ligaments which unite it to the trapezium. From these points the fleshy fibres proceed, forming two thick bundles, which are perfectly distinct above, and converge to a tendon, that is attached to the outer side of the first phalanx of the index finger.

Relations. It is covered behind by the skin; it corresponds in front to the adductor and flexor brevis pollicis, excepting below, where it is subcutaneous. Its lower edge, directed obliquely downwards and inwards, is immediately subcutaneous, and crosses the corresponding edge of the adductor pollicis at a very acute angle.

The Palmar Interossei.

These, like the preceding, are short, prismatic, triangular, and penniform muscles. They are three in number (*p p p*, *fig.* 123.) according to most authors, but four if we include the adductor pollicis. They all occupy the palm of the hand, as their name indicates, and extend from the entire length of one of the metacarpal bones bounding the interosseous space in which they are situated, to the first phalanx of one of the corresponding fingers, and to its extensor tendon.

They arise from about the anterior two thirds of the lateral surface of only one metacarpal bone; they are therefore covered behind by the dorsal interossei, which, being attached to the entire lateral surface of the other metacarpal bone, project equally into the palm. Lastly, their insertions into the phalanges and their extensor tendons correspond precisely with those of the dorsal interossei.

Relations. They are covered by the flexor tendons and by the muscles of the palmar region: each is in relation behind with a dorsal interosseous muscle; on one side, with the dorsal muscle of the corresponding finger; and on the other, with the metacarpal bone from which it arises.

Action. They are evidently adductors, as regards the axis of the hand, and, like the dorsal interossei, they bind down the extensor tendons; they can only act effectually when the fingers have been previously extended.

MUSCLES OF THE LOWER EXTREMITIES.

THE muscles of the lower extremity may be arranged in four groups, viz. those of the pelvis, of the thigh, of the leg, and of the foot.

MUSCLES OF THE PELVIS.

The glutæi, maximus, medius, et minimus. — Pyriformis. — Obturator internus. — Gemelli, superior et inferior. — Quadratus femoris. — Obturator externus. — Action of these muscles.

THE muscles of the pelvis are divided into those occupying the posterior and those occupying the anterior region. The former are very numerous, consisting

three glutæi, maximus, medius, and minimus, the pyriformis, the ob- internus, the gemelli, the quadratus femoris, and the obturator ex-

iliacus, which may with propriety be considered as belonging to the and as forming its anterior region, has been already described, together e psoas, under the name of the *psoas-iliac* muscle.

The Glutæus Maximus.

ection. Having placed the subject on its face, raise the pelvis by a flex the leg forcibly, and rotate it inwards; then make an oblique in- along the middle of the buttock, from the sacrum towards the great iter, dividing both the skin and fascia covering the muscle: dissect up flaps, one from below upwards, the other from above downwards, fol- the direction of the muscular fibres.

glutæus maximus (*a, fig.* 124.) is the most superficial of the muscles on the posterior aspect of the pelvis: it is broad, thick, and pretty regularly quadrilateral; it is the largest muscle of the human body — in this respect coinciding with the great size of the pelvis and femur in man; it causes the prominence of the buttocks. Its great size is one of the most distinctive characters of the muscular system of man, and has reference to his biped position.

Attachments (*see a, fig.* 125.). It *arises* from the posterior semicircular line of the ilium, and the portion of the bone behind that line; from the vertical sacro-iliac ligament, and the outer margin of the common aponeurosis of the posterior spinal muscles; from the crest of the sacrum, sometimes only from the tubercles which form a continuation of the transverse processes of the vertebræ on the outside of the posterior sacral foramina; from the edges of the coccyx, and the notch terminating the crest of the sacrum below, —this origin being often effected by means of a tendinous arch under which the last posterior sacral nerves pass; from the posterior surface of the great sacro-sciatic ligament; and, lastly, from the posterior surface of the aponeurosis of the glutæus medius. It is *inserted* (*a, fig.* 125.) into the rough line leading from the great trochanter to the linea aspera of the femur.

The fleshy fibres arise either directly or by short tendinous fibres, and proceeding parallel to each other outwards, and a little downwards, unite into large distinct fasciculi, capable of being separated through their entire length and constituting an extremely thick, quadrilateral, and very egular muscle, which, having reached the outside of the thigh, terminates by tendinous fibres. are received between two layers of the fascia lata, which is here very n passing downwards they converge, escape from the fascia lata, curve the base of the great trochanter, or rather the tendon of the vastus s, from which they are separated by a synovial bursa, and are succes- nserted by so many large fasciculi into the series of tubercles and ions, extending from the great trochanter to the linea aspera, and from ernal bifurcation of that line. The lower fleshy fibres are attached di-

palmar fascia. A distinct cellular line, or rather an aponeurotic septum, intervenes between one of their lateral surfaces and the corresponding palmar interosseous muscle; the other lateral surface is in relation through its entire length with the metacarpal bone on which it is implanted.

Action. These muscles are evidently abductors of the first phalanges of the fingers, the axis of the hand being taken as the point of departure. Their insertion into the extensor tendons explains why previous extension of the fingers is necessary to the movement of abduction.

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Relations. They are covered by the flexor tendons and by the muscles of the palmar region: each is in relation behind with a dorsal interosseous muscle; on one side, with the dorsal muscle of the corresponding finger; and on the other, with the metacarpal bone from which it arises.

Action. They are evidently adductors, as regards the axis of the hand, and, like the dorsal interossei, they bind down the extensor tendons; they can only act effectually when the fingers have been previously extended.

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The muscles of the pelvis are divided into those occupying the posterior and those occupying the anterior region. The former are very numerous, consisting

of the three glutæi, maximus, medius, and minimus, the pyriformis, the obturator internus, the gemelli, the quadratus femoris, and the obturator externus.

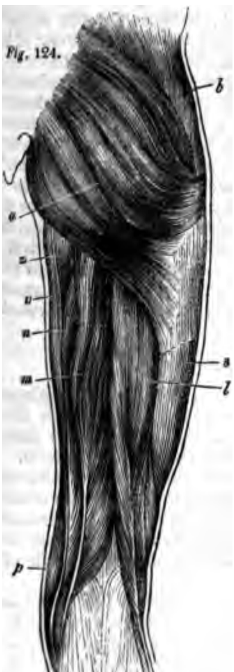
The iliacus, which may with propriety be considered as belonging to the pelvis, and as forming its anterior region, has been already described, together with the psoas, under the name of the *psoas-iliac* muscle.

The Glutæus Maximus.

Dissection. Having placed the subject on its face, raise the pelvis by a block, flex the leg forcibly, and rotate it inwards; then make an oblique incision along the middle of the buttock, from the sacrum towards the great trochanter, dividing both the skin and fascia covering the muscle: dissect up the two flaps, one from below upwards, the other from above downwards, following the direction of the muscular fibres.

The *glutæus maximus* (*a*, *fig.* 124.) is the most superficial of the muscles on the posterior aspect of the pelvis: it is broad, thick, and pretty regularly quadrilateral; it is the largest muscle of the human body — in this respect coinciding with the great size of the pelvis and femur in man; it causes the prominence of the buttocks. Its great size is one of the most distinctive characters of the muscular system of man, and has reference to his biped position.

Fig. 124.



Attachments (*see a*, *fig.* 125.). It *arises* from the posterior semicircular line of the ilium, and the portion of the bone behind that line; from the vertical sacro-iliac ligament, and the outer margin of the common aponeurosis of the posterior spinal muscles; from the crest of the sacrum, sometimes only from the tubercles which form a continuation of the transverse processes of the vertebræ on the outside of the posterior sacral foramina; from the edges of the coccyx, and the notch terminating the crest of the sacrum below, — this origin being often effected by means of a tendinous arch under which the last posterior sacral nerves pass; from the posterior surface of the great sacro-sciatic ligament; and, lastly, from the posterior surface of the aponeurosis of the glutæus medius. It is *inserted* (*a*, *fig.* 125.) into the rough line leading from the great trochanter to the linea aspera of the femur.

The fleshy fibres arise either directly or by short tendinous fibres, and proceeding parallel to each other outwards, and a little downwards, unite into large distinct fasciculi, capable of being separated through their entire length and constituting an extremely thick, quadrilateral, and very egular muscle, which, having reached the outside of the thigh, terminates by tendinous fibres. These are received between two layers of the fascia lata, which is here very thick; in passing downwards they converge, escape from the fascia lata, curve round the base of the great trochanter, or rather the tendon of the vastus externus, from which they are separated by a synovial bursa, and are successively inserted by so many large fasciculi into the series of tubercles and depressions, extending from the great trochanter to the linea aspera, and from the external bifurcation of that line. The lower fleshy fibres are attached di-

rectly to the linea aspera, and a certain number are inserted merely into the fascia lata. In order to obtain a good view of the femoral insertions of this muscle, its tendon must be separated from the fascia lata.

Relations. It is covered by a large quantity of fat, being separated from it by an expansion from the aponeurosis of the glutæus medius, from which are given off the cellular prolongations that divide the muscle into thick, parallel, and easily separable fasciculi.

It covers the glutæus medius, the pyriformis, the gemelli, the obturator internus, the quadratus femoris, the great sciatic notch, and the tuberosity of the ischium, together with the muscles attached to it, viz. the semi-tendinosus, the semi-membranosus, and the long head of the biceps. It covers also the great trochanter, the adductor magnus, and the triceps femoris, the glutæal, ischiatic, and internal pudic vessels and nerves, and the great sciatic nerves. Its upper border is very thin, and rests upon the glutæus medius; its lower border forms a very marked prominence beneath the skin, that affords the surgeon very precise indications, both in the diagnosis of many diseases of the hip joint; in operations performed for the purpose of reaching the tuberosity of the ischium, when it is either carious or necrosed; in those for the relief of sciatic hernia; or lastly, in searching for the sciatic nerve, whenever it becomes necessary to operate upon it. Several bursæ mucosæ, which have been well described by Monro, separate the glutæus maximus from the eminences which are covered by it. One of these separates it from the great trochanter, and is almost always multi-locular: I have seen it filled with a sanguineous synovia. A second exists over the tuberosity of the ischium, but is often wanting; and a third between the tendon of this muscle and the vastus externus.*

Action. The glutæus maximus is an *extensor*, an *abductor*, and a *rotator* of the thigh outwards. When the femur is fixed, as in standing, it acts upon the pelvis, which it draws backwards and to its own side, and rotates so that the anterior surface of the trunk is turned to the opposite side. Besides this it is easy to see that the lower fibres can act as adductors. By its connections with the fascia lata it is one of the principal tensors of this structure; by its attachment to the coccyx it tends to prevent that bone from being thrown backwards, forwards, or to one side.

The Glutæus Medius.

Dissection. Make a vertical incision through the middle of the glutæus maximus, or detach that muscle from the pelvis: remove the adipose tissue from the subcutaneous portion of the muscle, and also the fascia lata: dissect the tensor vaginæ femoris, which covers the anterior fibres of this muscle.

The *glutæus medius* (*b*, *figs.* 124. to 127.) is intermediate to the other two glutæi both as regards size and position; it is a broad, thick, radiated muscle, situated more deeply than the preceding, beyond which it projects upwards and forwards (*fig.* 124.). The glutæus maximus is attached to a small portion only of the iliac fossa: the glutæi medius and minimus share almost the whole of it between them.

Attachments. It *arises* from the whole extent of the curved triangular surface, included between the superior semicircular line behind, the anterior three fourths of the crest of the ilium above, and the inferior semicircular line below; from the anterior superior spine of the ilium and the notch immediately below it; from the deep surface of a dense aponeurosis, which is inserted into the outer lip of the crest of the ilium, covers all the upper portion of the muscle, and becomes continuous with the fascia lata: opposite the junction of the anterior with the middle third of the crest of the ilium, at which point a large tubercle exists upon the bone, this aponeurosis is so dense as to resemble a tendon. The muscle also arises from a deep aponeurosis, extending from the anterior part of the inferior semicircular line, and giving attachment, on its external surface, to a great number of fleshy fibres; and lastly, from the fascia

* See note, p. 389.

lata internally to the tensor vaginæ femoris. It is *inserted* into the external surface of the great trochanter (*figs.* 125. 127.).

From these numerous origins the fleshy fibres proceed in different directions; the posterior forwards, the middle vertically, and the anterior backwards, becoming more and more horizontal in front. They all terminate upon the two surfaces and edges of a radiated aponeurosis, the fibres of which are gradually concentrated and folded upon themselves, so as to form a flat tendon, inserted, not into the upper border, as it is generally said, but into the external surface of the great trochanter, along an oblique line running downwards and forwards, so that the anterior fibres of the muscle are inserted into the anterior extremity of the lower border of the great trochanter, and the posterior fibres into the back part of the upper border; at this latter point a well marked projection sometimes exists, the size of which generally indicates the power of the glutæus medius. A synovial bursa intervenes between the tendon and that part of the great trochanter over which it passes.*

Relations. It is covered by the glutæus maximus, the tensor vaginæ femoris, and the skin: it covers the glutæus minimus, with which its outer border is blended, and the glutæal vessels and nerves. Its lower border is parallel with the pyriformis (*fig.* 125.).

Action. The glutæus medius is both an *extensor* and an *abductor of the thigh*. Moreover, the anterior fibres rotate the femur inwards, and the posterior outwards; but the former have the greater power, for they are more numerous, the muscle being twice or thrice as thick in front as behind; it is therefore an *extensor*, an *abductor*, and a *rotator inwards of the thigh*. Winslow denies that it is an extensor, and considers it only as an abductor; this is only true in the position of standing upon both feet. In the sitting posture, again, this muscle in some degree loses its power as an extensor and abductor, and acts merely as a rotator. When the femur is fixed, as in standing, the glutæus medius extends the pelvis, draws it to its own side, and rotates it, so that the front of the trunk is turned towards the same side. It co-operates with the glutæus maximus in the first two motions, but antagonises it in the last. Finally, its anterior fibres appear to me calculated to flex the thigh upon the pelvis; especially when the flexion has been already commenced by other muscles.

The Glutæus Minimus.

The *glutæus minimus* (c, *fig.* 127.) is exposed by simply cutting across the preceding muscle, beneath which it lies; it is thinner and more regularly radiated. It *arises* from the anterior part of the crest of the ilium below the glutæus medius, from the outside of the sciatic notch, and from all that part of the external iliac fossa situated below the inferior semicircular line: from these points the fibres converge, the middle passing vertically, the posterior forwards, and the anterior backwards, to the deep surface of a radiated aponeurosis, the fibres of which are collected together into bands, that are *inserted* separately into the anterior border and anterior half of the upper border of the great trochanter. Most commonly the posterior band is intimately attached to the tendon of the pyriformis.

Relations. It is covered by the glutæus medius with which its anterior fibres are blended; it covers the external iliac fossa, the reflected tendon of the rectus femoris, and the upper part of the hip joint, from which it is separated by some fatty cellular tissue.

Action. It is much more directly an abductor than the preceding muscles. Its anterior half rotates the thigh inwards, and its posterior half outwards. If the femur be fixed, it extends the pelvis, inclines it to its own side, and turns the anterior aspect of the trunk to the same side; by its anterior fibres it assists slightly in producing flexion.

General remarks upon the action of the glutæi. The three muscles we have

* See note, p. 389.

just examined, generally have their fixed points upon the pelvis; and, in this point of view, are of the greatest importance in the standing posture. By their means the pelvis, firmly held down from behind, is enabled to resist the effects of the weight of the trunk which tends to throw it forwards: hence the enormous developement of these muscles in man, evidently proving his destination for the erect position. These same muscles are the principal agents in the position of standing upon one foot, inclining the pelvis to their own side, and balancing the entire weight of the opposite side of the trunk. They also rotate the trunk, when the individual is standing upon one foot. They are all extensors and abductors; the glutæus maximus is a rotator outwards; the other two are rotators inwards. Hence we may understand how the thigh can be so powerfully rotated inwards, although there are no direct muscles for that purpose; while a great number are specially intended to produce rotation outwards, which movement, indeed, is performed much more energetically than rotation inwards.

The Pyriformis.

Dissection. Detach the glutæus maximus, and separate the pyriformis from the lower border of the glutæus medius to which it is parallel. In order to see the sacral attachments of the muscle, make an antero-posterior section of the pelvis.

The *pyriformis* or *pyramidalis* (*d*, *fig.* 125.) is sometimes double: it is a flat muscle of a pyriform or rather pyramidal shape, lying almost horizontally along the lower margin of the glutæus medius, with which it seems to be continuous, and is sometimes intimately united: it is partly situated in the cavity of the pelvis, and assists in filling up the sciatic notch.

Attachments. It *arises* from the anterior surface of the sacrum (*p*, *fig.* 111.), in the intervals between the grooves forming the continuations of the anterior sacral foramina, and also opposite those grooves by three or four digitations, which are sometimes traversed by the great sciatic nerve: these origins are sometimes concentrated into a small space around the second and third anterior sacral foramina. It also arises from the anterior surface of the great sacro-sciatic ligament, and from the upper part of the sciatic notch. It is *inserted* into the back part of the upper edge of the great trochanter. The fleshy fibres pass from their origins almost horizontally outwards and a little backwards, and form a muscle which fills up the upper part of the great sciatic notch, and becoming much narrower immediately after emerging from the pelvis, from the convergence of its fibres, terminates on the posterior surface and edges of an aponeurosis, which is afterwards converted into a round tendon, and is fixed to the upper border of the great trochanter behind the glutæus minimus, and above the gemelli and obturator internus with which it is almost always intimately connected.

Relations. Its anterior surface is in relation with the rectum, the sciatic plexus, and the hypogastric vessels within the pelvis, and with the hip joint outside that cavity; its posterior surface with the sacrum and the glutæus maximus; its upper margin with the glutæal vessels and nerves, which separate it from the glutæus medius; its lower margin with the ischiatic vessels, and with the great and small sciatic nerves. Sciatic herniæ take place between the upper margin of this muscle and the sciatic notch. Sometimes the muscle reaches the summit of the notch; occasionally a considerable interval exists between them; in such cases there is a predisposition to this species of herniæ.

The Obturator Internus.

The *obturator internus* (*e*, *fig.* 125.) is a triangular reflected muscle, extending from the inner surface of the margin of the obturator foramen to the digital cavity of the great trochanter. Its course and direction are alike remarkable.

Attachments. It *arises* from the posterior surface of the obturator ligament, rom the pelvic fascia lining the inner surface of this muscle, and from the ndinous arch which converts the *sub-pubic groove* into a canal; also, from the ntire circumference of the obturator foramen, viz. from the internal surface f the descending ramus of the pubes and the ascending ramus of the ischium, nd from the whole extent of the quadrilateral surface situated between the bturator foramen and the sciatic notch; and lastly, by a few fibres from the rim of the pelvis. It is *inserted* into the digital cavity of the great trochanter. 'he fleshy fibres arise directly from this extensive surface, and converging ownwards and outwards, pass out of the pelvis through a triangular opening rmed by the spine of the ischium and lesser sacro-sciatic ligament above, y the great sacro-sciatic ligament on the inside, and by the body of the chium on the outside. At its exit from the pelvis the muscle becomes much arrower, is reflected at a right angle over the body of the ischium as over a ulley, is next received into a groove formed for it by the gemelli, and proceeds orizontally outwards to be inserted into the digital cavity of the great trohanter below the pyriformis. In order to obtain a good view of the structure f this muscle, it must be detached from its insertion and turned inwards. We hall then perceive that the tendon divides into four or five diverging portions pon the deep surface of the muscle, which are lost in its interior. A well iarked synovial membrane* intervenes between the tendon and the trochlear urface on the body of the ischium, which is covered with cartilage that is treaked, as it were, in the direction of the movements. Cowper and Douglas lluded to the presence of this bursa when they named the muscle *marsupialis el bursalis.*

Relations. In the pelvis the obturator internus is in relation with the obrator ligament and the circumference of the obturator foramen, by its anterior urface; and with the pelvic fascia and levator ani muscle, which separates it rom the bladder, by its posterior surface. During its passage through the orice I have described, it is in relation with the internal pudic vessels and nerves; xternally to the pelvis, it is covered by the great sciatic nerve and the glutæus iaximus, and it covers the hip joint.

From the great extent of the pelvic origins of this muscle, almost the whole f the anterior and lateral parietes of the pelvis are covered internally by a yer of muscular tissue; the posterior wall is also in a great measure covered y the pyriformis.

The origins of the muscular fibres from the tendinous arch of the obturator gament are so arranged, that the contraction of the muscle can have no effect i diminishing the size of the sub-pubic foramen intended for the passage of essels and nerves. There are sometimes two small tendinous arches; one foı ie nerve, the other for the artery and vein.

The Gemelli, Superior et Inferior.

The *gemelli* (gemini, *Albinus*; les petits jumeaux, *Winslow*, *f* and *g*, *fig.* 125.), wo small fleshy fasciculi, accessories to the obturator internus, are generally istinguished by anatomists into the *superior* (*f*) and the *inferior* (*g*); they re separated from each other by the tendon of the obturator internus, for the eception of which they form a groove. Above and below this groove they ıke their origin, the *superior* from the spine of the ischium, and the *inferior*, rhich is the larger, from the tuberosity of that bone immediately above the ttachment of the great sacro-sciatic ligament, and even slightly from the ligaıent itself. They both pass horizontally outwards; are sometimes united ither behind or in front of the tendon of the obturator internus, which they hen completely embrace, and with which they are entirely or partially blended, eing *inserted* with it into the digital cavity of the great trochanter.

Their *relations* are the same as those of the reflected portion of the obturator

* See note, p. 389.

internus. The gemellus superior is often wanting, and the inferior is frequently double. I have several times seen the superior terminate in the tendon of the pyriformis, and the inferior in the tendon of the obturator internus.

Action. They rotate the thigh outwards. Their relations with the synovial capsule of the obturator internus led to their being designated marsupiales by *Cowper;* and by *Portal,* le muscle capsulaire de la capsule du tendon de l'obturateur interne.

The Quadratus Femoris.

This muscle (*i*, *fig.* 125.), shaped like a parallelogram, is situated immediately below the gemellus inferior. It *arises* from the external border of the tuberosity of the ischium, in front of the semi-membranosus, from which it is separated by adipose tissue. From this point the fibres proceed horizontally outwards, parallel to each other, and are *inserted* into "an oblong ridge* projecting partly from the back of the root of the great trochanter, and partly from the femur immediately below it;" but above the attachment of the adductor magnus, with which, at first, it appears to be continuous, but from which it is always separated by the internal circumflex vessels.

This muscle is sometimes wanting; but very frequently its pelvic attachments are prolonged as far as the ascending ramus of the ischium; in which cases it is twisted inferiorly upon itself so as to oppose a surface, not a border, to the adductor magnus. Its relations behind are the same as those of the preceding muscles; in front, it covers the obturator externus and the lesser trochanter, from which it is often separated by a synovial capsule.

The Obturator Externus.

Dissection. The lower or horizontal portion of the obturator externus is exposed, by dividing the quadratus femoris into two equal parts by a vertical incision. In order to see the upper or pelvic portion, it is necessary to detach the gracilis, pectineus, psoas, iliacus, and adductor brevis.

This is a triangular flat muscle (*e*, *fig.* 127.), of the same shape, but thinner and smaller, than the obturator internus, and like it reflected, though at an obtuse angle. It *arises* from the circumference of the obturator foramen, from the obturator ligament, and from the tendinous arch which completes the sub-pubic canal for the vessels and nerve. It is *inserted* into the deepest and lowest part of the digital cavity of the great trochanter. The fleshy fibres arise directly, the lower ones proceed horizontally outwards, and the upper obliquely downwards, backwards, and outwards; thus converging they form a fleshy belly which turns round the neck of the femur, and terminates in a tendon that passes horizontally outwards, to be *inserted* into the digital cavity below the gemelli and the obturator internus.

Relations. Its outer and anterior surface is in relation with the pectineus, the adductors, the psoas and iliacus muscles, and more externally with the neck of the femur and the lower part of the capsular ligament of the hip joint. Its inner and posterior surface is in contact with the obturator foramen and the quadratus muscle.

Action of the preceding Muscles.

The last six muscles are evidently rotators of the thigh outwards. The pyriformis, the gemelli, and the obturator internus, which are almost always united at their insertions, would deserve the name of *quadri-gemini,* given by the older anatomists to the gemelli, the pyriformis, and the quadratus. When they take their fixed point upon the femur, as, for example, in standing upon one

* [M. Cruveilhier states the *insertion* of the quadratus femoris to be into the inter-trochanteric line. The description in the text, copied from Albinus, gives a more accurate idea of the insertion of this muscle.]

foot, they become rotators of the pelvis, and turn the anterior surface of the trunk to the opposite side. They are only rotators when the limb is extended; in the sitting posture, they become abductors. Winslow, who first demonstrated their use in abduction in the semiflexed position, attached great importance to the connection of so many of these muscles with the capsular ligament, which he believed prevented pinching of the capsule during the different movements of the joint.

The insertion of these muscles is exceedingly favourable. Moreover, we shall find that besides the glutæus maximus and the posterior fibres of the glutæus medius and minimus, they have many other muscles as accessories in rotation. The effects produced by the contraction of the two obturators can be easily understood, if we bear in mind that the action of a reflected muscle is to be calculated from the point of reflexion, leaving the rest of the muscle out of consideration. Thus, with regard to the obturator internus, the sciatic notch acts as a pulley, and may be regarded as the fixed point.

MUSCLES OF THE THIGH.

The biceps cruris. — Semi-tendinosus. — Semi-membranosus. — Tensor vaginæ femoris. — Sartorius. — Triceps extensor cruris. — Gracilis. — Adductor muscles of the thigh.

The muscles of the thigh are divided into those of the *posterior region*, viz. the biceps, the semi-tendinosus, and the semi-membranosus; those of the *external region*, viz. the tensor vaginæ femoris and the vastus externus; those of the *anterior region*, viz. the sartorius, the rectus, and the triceps extensor cruris of authors; and lastly, those of the *internal region*, viz. the gracilis, the pectineus, and the three adductors.

Posterior Region.

The Biceps Cruris.

Dissection. This is the same for the biceps, the semi-tendinosus, and the semi-membranosus. Place the subject upon its face, with a block under the pelvis, and allow the leg to hang over one side of the table. Make an incision from the middle of the space between the tuberosity of the ischium and the great trochanter, to the interval between the two condyles of the femur. Both the skin and the fascia of the thigh must be divided in this incision. Cautiously remove the cellular and adipose tissue surrounding the subjacent muscles, the relations of which with the popliteal vessels and nerves must be carefully studied. In preparing the superior attachments of these muscles, the glutæus maximus must be divided in the middle, perpendicularly to its fibres.

The *biceps femoris* (biceps cruris, *Albinus, l, figs.* 124, 125.), so named because it consists of two fleshy bodies or heads above, is a long large muscle, situated on the posterior and external aspect of the thigh.

Attachments. It *arises* from the tuberosity of the ischium and the linea aspera of the femur; and is *inserted* into the head of the fibula, and slightly into the external tuberosity of the tibia. Its origin from the ischium (*l, fig.* 125.) is common to it and the semi-tendinosus; it takes place not from the tuberosity properly so called, but from the highest and most external part of the tuberosity, above and behind the adductor magnus, and immediately below the gemellus inferior. It arises by a tendon which is seldom completely free from muscular fibres. This tendon, at first very thick and separated from the tuberosity of the ischium by a synovial bursa, expands into an aponeurosis which gives origin to the fleshy fibres of the biceps by its external edge and posterior surface, and to those of the semi-tendinosus by its internal surface. Up to this point the biceps and semi-tendinosus are blended together so as to form a single fleshy belly, which, after extending from two to four inches, is divided into two portions: one posterior and external, constituting the *long head*, or *ischiatic portion of the biceps;* the other anterior, forming the origin of the semi-tendinosus, which we shall next describe. Arising thus in succession, the fleshy fibres of the long head of the biceps form a fusiform belly passing ob-

liquely downwards and a little outwards, and terminating on the anterior surface of an aponeurosis which extends for a considerable distance on the posterior surface of the muscle, and which gradually becomes contracted so as to form the terminal tendon. Just where these fleshy fibres are about to terminate (*l, fig.* 125.), the aponeurosis receives upon its anterior surface and external edge the fleshy fibres of the *short head,* or *femoral portion* of the biceps. This portion of the muscle (*l', fig.* 125.) arises from the greater part of the interval between the two margins of the linea aspera, and the posterior surface of the external inter-muscular septum of the thigh; it passes downwards, inwards, and backwards, to be attached to the common tendon almost as far as its insertion. This insertion is not confined to the head of the fibula, but extends also to the external tuberosity of the tibia by means of a strong division of the tendon, which, at the same time, gives off an expansion to the fascia of the leg. The insertion into the fibula is effected on the outer side, in front of and behind the external lateral ligament of the knee joint, which ligament it embraces in a bifurcation.

Fig. 125.

Relations. The biceps is covered by the glutæus maximus and the femoral fascia. It covers the semi-tendinosus, semi-membranosus, and vastus externus. It is in relation, also, with the great sciatic nerve, which is placed at first externally, then in front, and lastly on the inside of the muscle; finally, its short head is in relation with the popliteal vessels.

The biceps forms the external border of the popliteal space; near its termination it is in relation with the outer head of the gastrocnemius and with the plantaris longus muscle.

Action. The biceps flexes the leg upon the thigh. When this movement is completed its long portion extends the thigh upon the pelvis. From its obliquity downwards and outwards, it rotates the leg outwards during semiflexion; but this rotation is impossible when the leg is extended, in consequence of the tension of the crucial ligaments. The fixed point of this muscle is as often below as above, and it then performs an important part in the mechanism of standing; for it tends to prevent the individual from falling forwards, because it holds back the pelvis. When the pelvis is thrown quite backwards, this muscle can then flex the thigh upon the leg.

The Semi-tendinosus.

The *semi-tendinosus* (*m, figs.* 124, 125.) so named on account of the great length of its tendon, is situated on the posterior and internal aspect of the thigh.

Attachments. It *arises* from the tuberosity of the ischium, and is *inserted* into the anterior tuberosity of the tibia. Its origin (*m, fig.* 125.) consists of a tendon common to it and the long head of the biceps, which is prolonged in the form of an aponeurosis, upon the external (or popliteal) border of the muscle. Some of the fleshy fibres are attached directly to the tuberosity of the ischium. Having arisen in this manner, it enlarges and constitutes a fusiform bundle, which passes at first vertically downwards, and then obliquely inwards. About four or five fingers' breadth above the knee joint it terminates in a

long thin tendon, which turns round the internal tuberosity of the tibia, describing a curve having its concavity directed forwards, and is then reflected horizontally forwards to be inserted into the anterior tuberosity of that bone, behind the tendon of the sartorius, and parallel with the lower edge of that of the gracilis to which it is united. The union of these three tendons constitutes the *patte d'oie* (goose's foot).

The length of its tendon of insertion is the most characteristic feature of the muscle; and hence its names, semi-nervosus (*Spigelius*), and le demi-nerveux (*Winslow*), for which the term semi-tendinous has now been substituted. The structure of this muscle is remarkable. The fleshy fibres are interrupted across the middle by a tendinous intersection, analogous to that of the great complexus, which gives origin to new fleshy fibres.

Relations. It is covered by the glutæus maximus and the femoral fascia, and it covers the semi-membranosus and part of the upper portion of the adductor magnus. Its tendon is first placed behind the semi-membranosus, and then, before it turns round the internal tuberosity of the tibia, between the tendon of that muscle and the inner head of the gastrocnemius.

Action. The same as that of the biceps. It is a very powerful flexor, on account of the reflexion of its tendon. Its oblique direction enables it to rotate the tibia inwards during semiflexion of the leg. It is, therefore, a congener of the popliteus.

The Semi-membranosus.

The semi-membranosus (*n, figs.* 124, 125.) is situated upon the posterior aspect of the thigh, thin and aponeurotic above, thick and fleshy below.

Attachments. It *arises* from the upper and outermost part of the tuberosity of the ischium, in front of the biceps and semi-tendinosus; and is *inserted* into the internal tuberosity of the tibia, and also, by an expansion of its tendon, into the femur. It arises by means of a very thick tendon, which becomes wider immediately after its origin. From its inner border is given off an aponeurotic lamina, that splits into two layers from the interval between which the superior fleshy fibres arise. Lower down, the muscular fibres proceed directly from the tendon itself, which runs along the outer (or popliteal) border of the muscle, as far as the lower fourth of the thigh, but is afterwards buried in its substance. The union of all these fibres constitutes a very thick four-sided fleshy belly, which is received into a tendinous semicone, open on its outer side, and soon becoming converted into a thick tendon, which, after a passage of a few lines, separates into three divisions, terminating in the following manner: — the *posterior* division passes inwards and upwards, forms the chief part of the posterior ligament of the knee joint, and is inserted into the femur; the *middle* division is attached to the back of the internal tuberosity of the tibia, below the articular surface; the *third* is horizontal, and turns round the internal tuberosity of that bone in the horizontal furrow existing there, and is inserted on the inner side of the tuberosity. A synovial bursa intervenes between it and the bone.

Relations. The semi-membranosus is covered by the glutæus maximus, the semi-tendinosus, the biceps, and the femoral fascia: it covers the quadratus femoris, the adductor magnus, and the inner head of the gastrocnemius. A synovial membrane separates it from the knee joint. It also covers the popliteal artery and vein, which soon come into relation with its outer or popliteal border. The sciatic nerve lies parallel with its outer border through the whole of its extent; the gracilis is in contact with its inner border. I shall remark here, that the biceps on the outside, and the semi-membranosus and semi-tendinosus on the inside, constitute the lateral boundaries of a cellular interval which extends along the whole of the back of the thigh, and is continuous with the popliteal space. This large cellular interval communicates above with the

cellular tissue of the pelvis at the sciatic notch, and below with the fossa of the ham. It is in this direction that purulent matter so readily escapes from the pelvis. The greater part of this interval is destined for the great sciatic nerve, which, however, is soon accompanied by the popliteal vessels.

Action. Precisely similar in nature to that of the preceding muscle, but much more powerful. The *momentum* of all these flexor muscles occurs, on the one hand, during semi-flexion of the leg upon the thigh; and, on the other (*i.e.* when their lower attachments are fixed), during semi-flexion of the thigh upon the pelvis.

External Region.

The Tensor Vaginæ Femoris.

Dissection. In order to expose this muscle, it is sufficient to make a vertical incision through the thick tendinous layer given off from the anterior portion of the crest of the ilium, and to dissect back the two flaps of that aponeurosis.

The *tensor vaginæ femoris* (le muscle du fascia lata, *o*, *fig.* 126.) is the largest of all the tensor muscles of aponeuroses: it is a short, flat, quadrilateral muscle, contained within the substance of the fascia lata, and occupying the upper third of the external region of the thigh. It *arises* from the anterior part of the outer margin of the crest of the ilium, and from the outer border of the anterior superior spinous process of the ilium, between the sartorius and the glutæus medius, by means of a tendon which also furnishes some points of attachment to the anterior fibres of the last named muscle. From these points the fleshy fibres proceed downwards and a little backwards, and, at about the upper fourth or third of the thigh, terminate in a series of small tendinous bundles, the anterior of which become continuous with the fascia lata, while the posterior cross obliquely over the vertical fibres of the fascia, with which they are very soon blended.

Relations. It lies between two layers of the fascia lata, the external layer being much thicker than the internal. It is covered by the skin, and it covers the glutæus medius, the rectus, and the vastus externus. Its anterior border is in contact with the outer edge of the sartorius, but is soon separated from it by a triangular space, in which the rectus femoris may be seen.

Action. It is a tensor, not only of the entire femoral fascia, but particularly of the very dense portion or band of the fascia lata, which, being continuous with it, may be regarded as an aponeurotic tendon to this muscle (muscle aponeurotique de la bande large, *Winslow*), and which is inserted into the outer tubercle of the anterior tuberosity of the tibia, and into the adjacent part of its external tuberosity. When the tensor vaginæ is in action, this band compresses the vastus externus, which has so great a tendency to displacement; by means of this band also the muscle acts upon and extends the leg. Lastly, on account of its slight obliquity downwards and backwards, it may be regarded as a rotator of the thigh inwards; it is but little concerned, however, in the production of this movement, which, as I have already said, is chiefly effected by the anterior fibres of the glutæi medius and minimus.

Anterior Region.

The Sartorius.

Dissection. This is common to all the muscles of the anterior and inner regions of the thigh. Make a horizontal incision along the femoral arch, and another perpendicularly from the middle of that to the anterior tuberosity of the tibia. Dissect the fascia of the thigh with care. As all the muscles of the anterior and inner region are separated from each other by distinct sheaths, their dissection consists simply in opening these sheaths successively and removing the cellular tissue that fills up the inter-muscular spaces. It is neces-

reserve the vessels in order to obtain a good view of their relations: ning the vena saphena, as it generally contains a large quantity of escape of which will impede the dissection. If the vein should be must be tied above and below the orifice, and then cut across. When ficial muscles have been studied, they must be divided in the middle, to expose the muscles of the deep layers.

rtorious (*p*, *fig.* 126.), so named on account of its uses, crosses diagonally over the anterior and then the inner part of the thigh to the top of the leg. It is the longest muscle in the body, both as regards its total length, and more especially in reference to the length of its fibres; whence the name of *longus* given to it by Riolanus. This is the case even although it be measured by a line stretched directly between its two extremities.

Fig. 126.

Attachments. It *arises* from the anterior superior spinous process of the ilium, from the upper half of the notch below that process, and from a tendinous septum between the muscle and the fascia lata. It is *inserted* into the inner margin of the crest of the tibia, situated beneath the ligamentum patellæ. Its origin consists of some tendinous fibres which are more marked behind and on the outer side than in front and within. The fleshy fibres commence almost immediately, and form a flat riband-like muscle (fascialis, *Spigelius*), which in reality is prismatic and triangular, as well as the tendinous sheath in which it is enclosed. The muscle increases in breadth as far as the lower third of the thigh, and passes obliquely downwards, inwards, and a little backwards; it becomes internal and vertical at the lower third (*p*, *figs.* 124, 125.), and reaches the back part of the inner condyle of the femur, to turn round the knee joint, tendinous fibres having already commenced on the anterior edge of the muscle. The fleshy fibres terminate precisely where the muscle changes its direction to pass forwards. The flat tendon by which they are succeeded is at first narrow, but becomes considerably expanded, to be inserted into the crest of the tibia, of the tendons of the semi-tendinosus and gracilis muscles, with which d, so as to form what is called the *patte d'oie* (goose's foot). A synovial e separates it from the tendons of these muscles. A considerable expansion is given off from its lower edge, and contributes to form part of the fascia of the leg.

ns. The sartorius is the most superficial muscle in the anterior the thigh: it lies beneath the femoral fascia, and covers the psoas us, the rectus, the vastus internus, the adductor longus, the gracilis, ctor magnus, and the internal lateral ligament of the knee joint. The f this muscle deserve particular attention, because incisions for ligahe femoral artery must be made along them. Its most important redeed, is with the femoral artery and vein; it is the *satellite* muscle of ral artery. Thus in the upper third of the thigh, it forms with the longus and femoral arch, an isosceles triangle having its base turned and the femoral artery represents a perpendicular drawn from the he base of the triangle. In the middle third of the thigh, the ar- relation, first, with the inner border, then with the posterior surface,

and lastly with the outer border of the muscle. In the lower third, the sartorius occupies a deep groove, formed by the gracilis and vastus internus; from the latter muscle it is separated below by an interval containing adipose tissue, of which circumstance advantage may be taken in the application of issues. It also covers the saphenus nerve (*a deep branch of the anterior crural*), which emerges from beneath its anterior border, opposite the lowermost point of insertion of the adductor magnus. Near the knee joint, the saphena vein is in relation with the posterior border of the muscle.

The structure of the sartorius is very simple. The fleshy and tendinous fibres are all parallel, and the former correspond exactly with the length of the muscle.

Action. The sartorius flexes the leg upon the thigh, which it draws inwards, so as to cross one leg over the other. When this movement is produced, it flexes the thigh upon the pelvis. If the fixed point of the muscle be at the leg, it then flexes the pelvis upon the thigh, and rotates it, so that the anterior surface of the trunk is directed to the opposite side.

The Rectus Femoris and Triceps Extensor Cruris, or the Triceps Femoralis.

I have included under the name *triceps femoralis* the two muscles, or rather the two parts of the same muscle, which are described separately in most anatomical works. The reasons for this arrangement will be understood after the following description of the muscle: —

I shall consider the triceps femoralis as composed of three portions viz. a *middle* or long portion, the *rectus femoris* of authors: an *external* and an *internal* portion, which constitute together the *triceps cruris* of authors; for these I shall retain the names of *vastus internus* and *externus*, including in the former the middle portion or *crureus*, properly so called, of most anatomists.

The *long portion of the triceps femoralis*, or the *rectus femoris* (*r*, *fig.* 126.), is situated in the anterior region of the thigh, extending from the anterior inferior spinous process of the ilium to the patella: it is vertical in its direction, thick and broad in the middle, and narrower at its extremities.

It *arises* by a very strong tendon (*r*, *fig.* 127.), which embraces the anterior inferior spinous process of the ilium, and is proportioned to the power of the muscle. This tendon receives on its outer side another flat tendon, arising from a groove upon the rim of the cotyloid cavity, and following its curvature: this is the *reflected tendon*, which is blended with and strengthens the *straight tendon*. It then expands into a broad aponeurosis, the outer portion of which is very thin and prolonged over the anterior surface of the muscle as far as the middle, while the inner portion is very thick, and penetrates into its substance nearly as far as its insertion. The fleshy fibres arise from the posterior surface and edges, and also from the anterior surface of the inner portion of this aponeurosis; they all pass downwards and backwards, the internal inwards and the external outwards, and form a fleshy belly, which increases as it proceeds downwards, and then terminates on the anterior surface of a broad, thick, and shining aponeurosis, occupying the lower two thirds of the posterior surface of the muscle, and soon becoming contracted into a flat tendon, which receives upon its inner edge the superficial fibres of the vastus internus, again expands, and is finally blended with the common tendon of the two vasti.

Triceps femoris of authors, or *vastus internus and externus*. This is a voluminous mass of muscular tissue, situated behind the preceding muscle, and extending from the three surfaces of the shaft of the femur to the patella and tibia. It is commonly but erroneously considered to be divided above into three heads, which are described under the names of *vastus internus*, *vastus externus*, and *crureus*. I have searched in vain for the middle portion, but have never been able to find more than two separate parts; one external, very large

and superficial, viz, the *vastus externus;* the other internal, anterior, and even external, viz. the *vastus internus:* it is much smaller than the vastus externus, and is partly covered by it and by the rectus.

The *external portion* or *vastus externus* (*s*, *figs.* 124. to 127.). This is the largest portion of the triceps femoralis. It *arises* from a projecting border or horizontal crest, situated at the base of the great trochanter, and from a vertical edge in front of that trochanter, which forms a continuation of its anterior border, and sometimes presents a very prominent tubercle: in the angle formed by these two attachments is situated the tendon of the glutæus medius. It also arises along a line running from the great trochanter to the linea aspera; and from the whole extent of the external lip of the linea aspera itself. All the preceding origins are effected by means of a broad aponeurosis which covers the superior three fourths of the muscle, and from the deep surface of which almost all the fleshy fibres proceed. Lastly, some of these arise from the tendon of the glutæus maximus, and from the tendinous septum intervening between the vastus externus and the short head of the biceps. From these origins the fleshy fibres proceed, some vertically downwards, the others somewhat obliquely downwards and forwards, the lowest being the shortest and the most oblique; they form a large bundle, which partially covers the anterior portion of the vastus internus, but is separated from it by vessels, nerves, and cellular tissue. After a course of variable length, some of the fleshy fibres are attached to the deep, but the greater number to the superficial, surface of another equally strong aponeurosis: this becomes thickened and contracted into a flat tendon, which is sometimes divided into thick parallel bands, emerges from the fleshy fibres at the external margin of the rectus, and is *inserted* into the outer half of the upper border of the patella, being blended on the inner side with the rectus and the vastus internus. The lower fleshy fibres which arise from the inter-muscular septum are attached directly to the outer border of the patella.*

The *internal* or *anterior portion*, *vastus internus* (*t* and *u*, *fig.* 127.), is much smaller than the external, and surrounds the femur. Its inner portion lies immediately under the fascia, and is the only part which is generally described as the *vastus internus* (*t*, *figs.* 126. 127.). Its anterior portion is covered by the rectus, or long portion, and is usually called the *crureus* (cruralis, *Alb.*, *u*, *fig.* 127.) Its outer portion is covered by the vastus externus, with which many of its fibres are blended; but they may always be separated by cutting along the outer margin of the middle aponeurosis. Thus defined, the vastus internus *arises* from a rough oblique line, extending from the front of the neck of the femur to the linea aspera, and from the internal lip of the linea aspera itself, in front of the adductor muscles: both of these origins are effected by means of an aponeurosis, which is weaker and smaller than that of the vastus externus, and is blended with that of the adductors, concurring with it in the formation of a canal for the femoral artery. It also arises from almost the whole of the internal, anterior, and external surfaces and from the two anterior borders of the femur; lastly, the lower fibres arise from the internal intermuscular septum. From these different origins, the fleshy fibres pass in various directions; the external inwards, the middle vertically, and the internal, which are the most numerous, downwards, forwards, and outwards; they thus form a fleshy belly, thicker below and within, than above and without, and are successively attached to both surfaces, and especially to the posterior surface of a broad aponeurosis, which is covered by the tendon of the vastus externus, but can be easily separated from it. The inner fibres are attached to the anterior surface of the aponeurosis, and terminate very regularly opposite a vertical line, running parallel to the inner margin of the rectus femoris.

The aponeurosis extends over the anterior surface of the middle portion of

* The anterior border of this tendon is free, and perfectly distinct from the tendon of the rectus, which is lined by it; and also from the expanded tendon of the vastus internus.

the muscle, which lies behind the rectus: this fact has doubtless given rise to its division into two parts, viz. a middle or the *cruræus*, and an internal called the *vastus internus*. The superficial layer of the internal fleshy fibres is attached below to the inner margin of the rectus, or long portion of the triceps femoralis: the lowest of these fibres, which arise from the inner and inferior bifurcation of the linea aspera, and from the corresponding inter-muscular septum, are almost horizontal, and accompany the tendon as far as its insertion into the inner border of the patella. Lastly, the terminating aponeurosis is prolonged inwards to the internal tuberosity of the tibia, below which it is inserted, being covered by the tendons of the semi-tendinosus, semi-membranosus, and gracilis muscles, on the inner side of the internal lateral ligament of the knee. This very strong aponeurotic insertion represents the fascia lata on this aspect of the limb, and forms an accessory internal lateral ligament.

From the above description it follows, that the triceps femoralis is composed of three muscles and three tendons, super-imposed upon each other, viz. the rectus femoris, the vastus externus, and the vastus internus.

Relations. The long portion of the triceps, or the rectus femoris, is covered by the fascia lata in its lower three fourths. Its upper part is covered by the sartorius, by the anterior fibres of the glutæus medius, and by the psoas and iliacus. It covers the hip joint, the anterior circumflex vessels, and the two vasti muscles. The vasti surround the femur as in a muscular sheath, and have relations with all the muscles of the thigh. They are superficial in a great part of their extent: in front, they are in relation with the psoas and iliacus, the rectus femoris, and the sartorius, and they lie immediately under the fascia, in the triangular spaces left between these muscles: behind, they are in relation with the biceps and semi-membranosus; on the inside, with the adductors, with the femoral artery, the sheath of which the vastus internus contributes to form, and with the sartorius; on the outside, with the glutæus maximus, which glides over the upper end of the vastus externus, and is separated from it by a synovial bursa; and lastly, with the tensor vaginæ femoris and the fascia lata. It is necessary to allude here to a small fleshy bundle, formed by the deepest and lowest fibres of the vastus internus, which is always distinct from the rest of the muscle, and is inserted into the upper part of the synovial membrane of the knee. This bundle has been regarded by Winslow as an articular muscle, intended to prevent the synovial membrane from being pinched between the surfaces of the joint.

Action. This muscle extends the leg upon the thigh; its action is facilitated by the existence of the patella, which serves to increase the angle of insertion, and which we have described as a sesamoid bone, developed in the substance of the tendon. We must, therefore, regard the triceps as inserted into the anterior tuberosity of the tibia, or rather into the lower part of that tuberosity. It should be observed, that the tendon is inserted into the patella, in front of its base, and not into the base itself, in the same manner as the ligamentum patellæ is attached to the anterior surface of that bone, and not to the rough mark on its posterior surface: this important arrangement increases the angle at which the moving power operates. The triceps femoralis is the most powerful muscle in the body, no other having such large surfaces of origin, and consequently so great a number of fibres. By itself it supports, in a state of equilibrium, the entire weight of the body in standing, and may be adduced as a striking example of the predominance of the extensors over the flexors: it is also this muscle which raises the whole trunk in progression and in the act of leaping. We cannot, therefore, be astonished at rupture of the patella, of its ligament, or of the common tendon, during a violent contraction of this muscle, notwithstanding its disadvantageous insertion so near to the fulcrum. The rectus necessarily acts with the two vasti, but it can also flex the thigh upon the pelvis. The somewhat oblique direction of the tendon of the triceps downwards and inwards, and of the ligamentum patellæ downwards and outwards, so that they form an obtuse angle, open to the outside (see *fig.* 126.),

and more especially the predominance of the vastus externus over the vastus internus, sufficiently account for the occurrence of luxation of the patella outwards, and for the impossibility of its being dislocated inwards.

When the patella is forced inwards by external violence, the contraction of the vastus externus draws it back into its original position: on the other hand, the action of this muscle has a tendency to displace it outwards; and when this is accomplished, the same muscle keeps it in its abnormal position. Luxations of the patella, therefore, if not altogether irreducible, can only be temporarily replaced; whenever the hand ceases to retain the bone in its proper place, the contraction of this muscle again dislocates it. Professor Ant. Dubois has informed me of an individual whose knees were bent very much inwards, who could not contract the triceps femoralis with any force without dislocating the patella outwards.

Internal Region of the Thigh.

The muscles of the internal region of the thigh are the gracilis and the adductors, among which I include the pectineus.

The Gracilis.

The *gracilis* (le grêle interne, ou droit interne, *Winslow, v, figs.* 124, 125, 126.) is a long, straight, and slender muscle, and the most superficial of those situated on the inside of the thigh.

Attachments. It *arises* from the symphysis pubis, between the pubic spine and the ascending ramus of the ischium, and is *inserted* into the spine of the tibia. It arises by some long, shining, and parallel tendinous fibres, which bind down a perpendicular fibrous bundle that lies on the inner side of the line of attachment. The fleshy fibres succeeding to these are at first parallel, and form a broad thin bundle; they then converge towards each other, so that the entire muscle resembles a much elongated isosceles triangle. It is rounded below, and terminates in a long thin tendon, which runs for a considerable distance upon its posterior border, and receives all the fleshy fibres in succession. This tendon becomes free immediately above the knee joint, is then situated behind the internal condyle of the femur, turns round this process and the corresponding tuberosity of the tibia, and is inserted into the spine of the last mentioned bone, behind the tendon of the sartorius, and above that of the semi-tendinosus, with both of which it is united so as to form the trifid aponeurotic interlacement, denominated *la patte d'oie* (goose's foot).

Relations. The gracilis is covered by the femoral fascia, and slightly by the sartorius at its lower part: it covers the three adductors, the inside of the knee joint, and the internal lateral ligament, from which it is separated by a synovial bursa common to it and the semi-tendinosus: the vena saphena interna crosses the inner surface of this muscle obliquely, near its lower extremity.

Action. It flexes the leg, and carries it slightly inwards at the same time by means of its reflection round the knee; in this part of its action it assists the sartorius; it also adducts the thigh. In the position of standing its moveable point is at the pelvis.

The Adductor Muscles of the Thigh.

There are three muscles on the inner aspect of the thigh which are called *adductors*, with these the older anatomists were acquainted under the collective name of the *triceps* adductor. Modern writers, however, describe them either in the order of their super-imposition, as the *first*, *second*, and *third* (*Boyer*); or in the order of their size, as the middle, small, and great adductors (*Bichat*). These vague denominations are the source of much confusion, for the one which occupies the middle place as regards size is the first as regards its po-

sition. I have therefore thought it right to modify these names, and have at the same time included the pectineus among the adductor muscles. I consider therefore that there are four adductors, which I shall divide into *superficial* and *deep*; the two superficial are the pectineus and the first or long adductor; these I shall term the *first* and *second*.

Superficial adductors. The two deep are the short and the great adductors, which I shall denominate the *small deep adductor*, and the *great deep adductor*. Strictly speaking we could only admit the existence of two adductors, one *superficial*, the other *deep*; and this mode of division would perhaps be preferable.

Dissection. This is common to all the adductors. Abduct the thigh so as to render these muscles tense. Make an incision through the integuments from the middle of the femoral arch to the patella, and a semicircular incision at either end of this; preserve the vessels and nerves in order to examine their relations; tie and cut across the vena saphena where it enters the femoral vein; divide the fascia lata, and dissect the muscles, which will then be brought into view.

The First Superficial Adductor, or Pectineus.

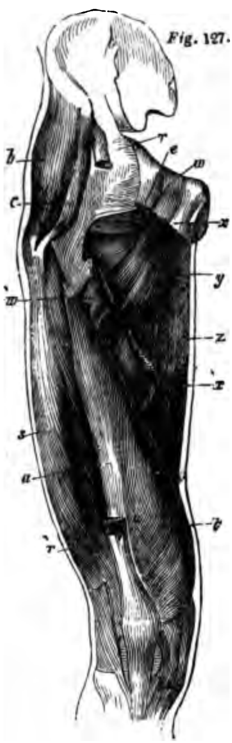


Fig. 127.

The pectineus (*pecten*, the pubes) is a square muscle (*w*, *fig.* 126.), situated at the upper anterior and inner aspect of the thigh, on the inner side of the psoas and iliacus (*c*).

Attachments. It *arises* (*w*, *fig.* 127.) from the spine and crest of the pubes, from the triangular surface in front of this crest, and from the lower surface of a very strong tendinous and arched prolongation of Gimbernat's ligament, which is attached to the crest of the pubes, and is continuous with the fascia covering the muscle. It is *inserted* (*w*, *fig.* 127.) below the lesser trochanter, into the ridge extending from that process to the linea aspera. With the exception of the spine of the pubes, where there are always some well marked tendinous attachments, the fleshy fibres commence directly from the several origins: they proceed downwards, backwards, and outwards, and constitute a bundle which is at first flattened from before backwards, and afterwards from without inwards: the fibres of this after a short course converge, and are inserted into the internal bifurcation of the linea aspera, in part directly, and partly through the medium of an aponeurosis which occupies the anterior surface of the muscle.

Relations. The pectineus is covered by the deep layer of the femoral fascia and by the femoral vessels. It covers the capsular ligament of the joint, the small deep adductor, and the obturator externus, from which it is separated by the obturator vessels and nerves. Its outer border is parallel with the inner border of the conjoined portions of the psoas and iliacus, and is separated from them by a cellular interval, over which the femoral artery passes; so that were it not for the projection of this outer border, this vessel would be in immediate contact with the bone. Its inner border is in relation with the second superficial adductor, and is sometimes blended with it except below, where it is separated by an interval in which the small deep adductor may be seen. It has

an important relation with the anterior orifice of the sub-pubic canal, which corresponds with the posterior surface of the muscle. When hernial protrusions therefore take place at the foramen ovale the displaced parts are always covered by the pectineus muscle.

The Second Superficial Adductor, or Adductor Longus.

The adductor longus of *Albinus* (le premier adducteur, *Boyer;* le moyen adducteur, *Bichat, x, fig.* 126.) is a flat triangular muscle, situated on the same plane as the pectineus, of which it seems to be a continuation, and with which it is often blended above. For this reason Vesalius made of these two muscles his eighth pair of muscles of the thigh, under the name of *pars octava femur moventium.* It is certain that there is a sort of consolidation between these two muscles, and that a small pectineus is always observed in conjunction with a large adductor longus.

Attachments. It *arises* (*x, fig.* 127.) from the spine of the pubes, and is *inserted* (*x*) into the middle third of the linea aspera of the femur. Its origin consists of a narrow flat tendon, which expands anteriorly, and gives origin to a thick and broad fleshy belly; this passes downwards, backwards, and outwards, and is inserted into the middle third of the linea aspera of the femur, between the triceps femoralis in front, and the great deep adductor behind: with the latter of these muscles it becomes blended at its insertions. It is attached to the bone by means of two tendinous layers, beween which the fleshy fibres are received. A number of foramina, intended for the perforating arteries, are observed in the neighbourhood of this attachment.

Relations. Its upper part lies immediately under the fascia, and it becomes gradually deeper as it passes downwards. It is in relation with the sartorius, from which it is separated by the femoral artery and veins. This relation is one of great importance, as I shall hereafter have occasion to point out.

The Small Deep Adductor, or Adductor Brevis.

The adductor brevis of *Albinus* (le second of *Boyer;* le petit of *Bichat, y, fig* 127.) is of the same form as the preceding muscle, and is the second in the order of super-imposition, but the smallest in size. It *arises* below the spine of the pubes on the outer side of the gracilis, and the inner side of the obturator externus from a variable extent of surface. The fibres proceed outwards, downwards, and a little backwards, and form a thick bundle, at first flattened from within outwards, and then from before backwards, which increases in breadth, and terminates at the middle of the linea aspera of the femur, in front of the great deep adductor, and behind the two superficial adductors, with which it is blended at its insertion.

Relations. It is covered by the superficial adductors, and it covers the great deep adductor, or adductor magnus. Its outer border has a relation with the obturator externus, and the conjoined psoas and iliacus muscles; its inner border is at first in contact with the gracilis, and is then applied to the adductor magnus, from which it is sometimes difficult to separate it.

The Great Deep Adductor, or Adductor Magnus.

Dissection. In order to obtain a good view of this muscle, it is not sufficient to study its anterior surface only, which is exposed after the preceding muscles have been divided; its posterior surface must also be examined; and for this purpose it is necessary to remove the three muscles of the posterior region of the thigh, viz. the biceps, the semi-tendinosus, and the semi-membranosus.

The adductor magnus of *Albinus* (le troisième of *Boyer;* le grand of *Bichat, z z', figs.* 124. to 127.) is a very large triangular muscle, extremely thick internally, where it constitutes almost the entire substance of the inside of the

thigh (*fig.* 127.). It *arises* from the whole extent of the ascending ramus of the ischium, from a small part of the descending ramus of the pubes, and from the apex, *i. e.* the lowest portion, of the tuberosity of the ischium. It is *inserted* into the whole extent of the interval between the two lips of the linea aspera, and into a very prominent tubercle upon the inner condyle of the femur, above the depression for the insertion of the tendon of the inner head of the gastrocnemius. Its origins, especially those from the ischium, which are the principal, can only be seen on the posterior surface of the muscle (see *fig.* 125.). They consist of tendinous bundles, giving origin immediately to fleshy fibres, which form an extremely thick mass, directed downwards and outwards, and presenting coarse bundles, almost as large and as easily separable as those of the glutæus maximus. The muscle soon divides into two portions, or rather into two distinct muscles — an internal and an external.

The internal portion (*z*, *figs.* 125. 127.) forms the inner border of the adductor magnus, the original course of which it follows. About the lower third of the thigh, its fibres are received into a tendinous semi-cone, open on the outside, and terminating in a shining tendon, which is inserted into a well marked tubercle on the upper and back part of the internal condyle of the femur. Throughout its whole course, this tendon lies close to the aponeurosis of the vastus internus.

The external portion (*z'*, *fig.* 125.) abandoning the primitive direction of the muscle, is directed outwards, and separates into thick bundles, which are inserted into the whole extent of the interval between the lips of the linea aspera, by means of a very large aponeurosis, which is intimately united to the tendons of the other adductors, and forms a series of arches (see *fig.* 125.) for the passage of the perforating arteries.

These two divisions of the adductor magnus are separated below by the femoral artery and veins and their sheath, and are generally distinct for a considerable extent, and sometimes entirely so. I have met with a case of this kind. That portion of the muscle which was inserted into the internal condyle arose entirely from the apex of the tuberosity of the ischium; whilst the origin of that portion which was attached to the linea aspera, took place from a prominence situated on the external side of that tuberosity, and projecting outwards from it, and also from the ascending ramus of the ischium, and the descending ramus of the pubes, externally to the gracilis muscle. The superior fibres (*fig.* 125.) are horizontal, and forming a distinct and, as it were, a radiated bundle, turn in front of the succeeding fibres, and are inserted into the line leading from the great trochanter to the linea aspera internally to the glutæus maximus.

Relations. The adductor magnus is covered by the superficial adductors and by the small deep adductor: it covers the semi-tendinosus, the biceps, the semi-membranosus, and the glutæus maximus. Its inner border is bounded by the gracilis above, and by the sartorius below: its upper border is in contact with the obturator externus (*e*, *fig.* 127.) on the inside, and with the quadratus femoris (*i*, *fig.* 125.) more externally. Its most important relation is that with the femoral artery and vein, which pass through it before reaching the popliteal space. At the place where this perforation occurs, we observe a tendinous arch, or rather canal, into which the fleshy fibres are inserted; and so, also, where the perforating arteries pass through this muscle.

Action of the adductor muscles. The muscles we have just described are both flexors and rotators outwards; but their principal office, as their name indicates, is to perform adduction, a very energetic movement, as might be anticipated from the strength of the muscles concerned in its production. We have seen, indeed, that the line of origin extends from the ilio-pectineal eminence, as far as and including the tuberosity of the ischium; and that the insertions occupy the entire length of the linea aspera, the two branches of its superior bifurcation, and the inner condyle of the femur. These muscles are

werfully exerted during equestrian exercise; it is by their means that the rse is firmly grasped between the knees. The two superficial adductors and ; adductor brevis are also flexors, because their insertions are posterior to ir origins. All the adductors are, as it were, rolled around the femur during ation inwards.

MUSCLES OF THE LEG.

e tibialis anticus.— Extensor communis digitorum. — Extensor proprius pollicis. — Peroneus longus and brevis. — Gastrocnemius, plantaris, and soleus. — Popliteus. — Tibialis posticus. — Flexor longus pollicis.

IE muscles of the leg may be divided into those of the anterior, those of the ternal, and those of the posterior regions.

Muscles of the Anterior Region of the Leg.

The muscles of the anterior region of the leg are the tibialis, the extensor mmunis digitorum, and the extensor proprius pollicis pedis. The anterior roneus, or peroneus tertius, when it exists, is nothing more than an accessory sciculus of the extensor communis.

The Tibialis Anticus.

Dissection. Make a vertical incision through the skin from the anterior berosity of the tibia to the middle of the inner border of the foot; dissect ck the two flaps of skin, and expose the fascia of the leg; divide this fascia vertically, commencing from the middle of the leg, and terminating at the lower end of the tibia, taking care to preserve the annular ligament: prolong the dissection and separation of the fascia as far upwards as possible; lastly, remove the fascia on the dorsum of the foot, which covers inferiorly the tendon of the tibialis anticus.

Fig. 128.

The tibialis anticus (*a*, *fig.* 128.) is a long, thick, prismatic, and triangular muscle, placed superficially along the outer side of the tibia.

Attachments. It *arises* from the crest which bounds the anterior tuberosity of the tibia on the outside, and from the tubercle terminating this crest above; from the external tuberosity of the tibia, and the superior two thirds of its external surface, which presents a depression proportioned to the strength of the muscle; from all that portion of the interosseous ligament situated to the inner side of the anterior tibial vessels and nerves; from the deep surface of the fascia of the leg; and lastly, from a tendinous septum intervening between this muscle and the extensor communis digitorum. It is *inserted* into the tubercle on the first or internal cuneiform bone, and sends off a tendinous expansion to the first metatarsal bone.

It *arises* from the internal surface of an osteo-fibrous quadrangular pyramid formed by the tibia, the fascia of the leg, the interosseous ligament, and the intermuscular septum; from these points the fleshy fibres proceed vertically downwards, and terminate around a tendon which commences in the substance of the muscle above its middle third; the anterior fibres cease at the lower third of the muscle, the posterior accompany the tendon to the point where it passes under the dorsal ligament of the instep (seen in *fig.* 128.). As soon as the tendon appears on the anterior border of the muscle, it is deflected forwards in a milar manner to the external surface of the tibia, and follows the same ob-

lique course, after having left the common sheath of all the muscles of the anterior region of the leg. Another sheath, which is nothing more than the condensed dorsal fascia of the foot, receives the tendon at the point where it passes vertically downwards, to be inserted into the tubercle of the first cuneiform bone.

Relations. The tibialis anticus is covered by the fascia of the leg and the dorsal fascia of the foot; on the inside it is in relation with the external surface of the tibia; on the outside, at first with the extensor communis digitorum, and then with the extensor proprius pollicis, from which it is separated behind by the anterior tibial vessels and nerves.

Action. It flexes the foot upon the leg; and from the obliquity of its tendon it raises the internal border of the foot, and consequently produces that sort of rotation inwards at the articulation of the two rows of the tarsus which we have already alluded to. It tends also to adduct the ankle joint, and is consequently opposed to dislocation outwards. The absence of a proper sheath for this muscle, explains the considerable projection formed by its tendon during contraction, which may serve as a guide to the preliminary incisions in ligature of the dorsal artery of the foot. Spigelius called this muscle the *musculus catenæ*, because fetters applied around the ankles of criminals press chiefly upon the projection formed by its tendon.

The Extensor Longus Digitorum Pedis, and the Peroneus Tertius vel Anticus.

Dissection. Remove the fascia of the leg and the dorsal fascia of the foot.

This is an elongated, semi-penniform, and reflected muscle (*b c*, *fig.* 128.), flattened from within outwards, single above, and divided into four or five tendons below.

Attachments. It *arises* from the external tuberosity of the tibia, on the outer side of the tibialis anticus; from the whole of the internal surface of the fibula in front of the interosseous ligament, and slightly from that ligament; from the upper part of the fascia of the leg, and from the tendinous septa interposed between this muscle and the tibialis anticus within, and the peroneus longus and brevis without. It is *inserted* into the second and third phalanges of the last four toes.

From these numerous origins the fleshy fibres proceed in different directions; the superior vertically downwards, the rest obliquely downwards and forwards, the lowest being the most oblique; they all terminate around a tendon, which appears upon the anterior border of the muscle below the upper third of the leg. This tendon soon divides into two portions: one internal, and itself subdivided into three tendons for the second, third, and fourth toes; the other external, and generally split into two tendons, one of which is intended for the fifth toe, while the other is fixed to the posterior extremity of the corresponding metatarsal bone. This last subdivision is often wanting; it is but imperfectly separated from the fasciculus belonging to the fifth toe, to which it almost always sends off an accessory tendon: it has been generally described as a separate muscle, under the name of the peroneus tertius or anticus (*c*, *fig.* 128.). I have thought it right, however, to connect this muscle with the extensor longus digitorum (*b*), from which it can be so imperfectly separated that it has been designated by *Cowper*, pars extensoris digitorum pedis longi; and by *Morgagni*, quintus tendo extensoris longi digitorum pedis.

The extensor communis is directed vertically as far as the ankle joint, where it enters a sheath common to it and the flexor proprius pollicis, is next reflected under this sheath, becomes horizontal, passes obliquely inwards and opposite the tarsus, is received into a much stronger proper sheath, after leaving which the five tendons separate so as to cover the dorsal surface of the metatarsal bone of the toes, to which they correspond. In this course they cross the extensor brevis digitorum at a very acute angle, reach the dorsal surface of

the metatarsal phalangal articulations, apply themselves to the inner edges of the corresponding tendons of the extensor brevis, receive some expansions from the interossei and lumbricales, and are arranged in precisely the same manner as the extensor tendons of the fingers, forming a fibrous sheath on the dorsal surface of the first phalanx of the toes; and like these, having arrived at the articulations of the first with the second phalanges, each divides into three portions; one median attached to the posterior extremity of the second phalanx, and two lateral, which unite upon the dorsal surface of the second phalanx to be inserted into the posterior extremity of the third.

Relations. Internally this muscle is in relation with the tibialis anticus, from which it is soon separated by the extensor proprius pollicis, and externally with the peroneus longus and brevis. It is covered by the fasciæ of the leg and foot, and it covers the fibula, the interosseous ligament, the ankle joint, the extensor brevis digitorum, which separates it from the tarsus and metatarsus: lastly it covers the toes.

Action. As in all reflected muscles, we must suppose the power to be exerted immediately after its reflexion, and in the direction of the reflected portion: in this way it will be seen, that it extends the third phalanges upon the second, and the second upon the first; and having produced this effect, it flexes the foot upon the leg. From its obliquity it also draws the toes outwards, and turns the sole of the foot inwards.

The Extensor Proprius Pollicis.

The extensor proprius pollicis (*d, fig.* 128.) is an elongated, thin, flat muscle, placed in front of the leg, between the extensor longus digitorum, and the tibialis anticus.

Attachments. It *arises* from the internal surface of the fibula, and slightly from the adjacent part of the interosseous ligament, within and behind the extensor communis. This origin is situated at variable heights, but commonly not above the middle third of the leg. It is *inserted* into the posterior extremity of the second phalanx of the great toe. The fleshy fibres arise directly from the fibula and the interosseous ligament, and proceed at first vertically around, and then obliquely behind a tendon, which occupies the anterior border of the muscle, and to which the fleshy fibres are all attached in a sloping manner, like the barbs of a feather, as far down as below the proper sheath formed for it at the tarsus. From thence the tendon is reflected at a right angle, proceeds obliquely and horizontally forwards and inwards upon the dorsum of the foot, passes along the dorsal surface of the first metatarsal bone and first phalanx of the great toe, to the latter of which it gives off a prolongation on each side, and is then inserted into the second phalanx.

Relations. Internally, it is in relation with the tibialis anticus, from which it is separated behind by the anterior tibial nerve and vessels; and externally, with the extensor longus digitorum. Its anterior border, at first concealed between the preceding muscles, is soon situated immediately beneath the fascia, and during its contraction forms a projection, which it is important to know, because it serves as a guide in searching for the dorsal artery of the foot, which will always be found on the outer margin of the tendon: it may be called the *muscle of the arteria dorsalis pedis.* In the foot it crosses superficially to the extensor brevis digitorum.

Action. It extends the second phalanx of the great toe upon the first, and that upon the metatarsus; when this is accomplished, it flexes the foot upon the leg. In consequence of its obliquity, it tends, like the preceding muscle, to turn the toes outwards, and slightly to elevate the inner border of the foot.

External Region of the Leg.

In this region are found the peroneus longus and peroneus brevis muscles.

The Peroneus Longus.

Dissection. This is common to both muscles. Remove the skin on the outer side of the leg; make a vertical incision through the fascia; reflect the two flaps, in order to arrive at the tendinous septa dividing the peronei from the muscles of both the anterior and posterior regions of the leg. To expose these muscles in the foot, remove the outer portion of its dorsal fascia, and divide obliquely inwards and forwards all the muscles of the plantar region, from the groove of the cuboid to the posterior extremity of the first metatarsal bone.

The peroneus longus (*e, figs.* 128. to 130.) is a long thick muscle, prismatic and triangular at its upper part, and superficially situated on the outer side of the leg (peroneus primus, *Spigelius*).

Attachments. It *arises* externally from the outer and anterior part of the head of the fibula; from a small portion of the contiguous part of the external tuberosity of the tibia; from the upper third of the external surface of the fibula; and from the anterior and posterior borders of that bone, by means of very strong tendinous septa, interposed between it and the anterior and posterior muscles of the leg; lastly, from the fascia of the leg superiorly. It is *inserted* into the posterior extremity of the first metatarsal bone, on the outer side of which a process exists for this purpose.

From these very numerous origins, the fleshy fibres proceed vertically and form a bundle (*e, fig.* 130.), thick above, thin and flat below, and terminating in a tendon which is at first concealed in the substance of the muscle, but appears in the form of a band on its outer side a little above the middle of the fibula, and becomes narrower and thicker as it proceeds. The tendon soon leaves the fleshy fibres, and accompanies the external surface of the fibula as it turns backwards (peroneus posticus, *Riol*), then passes behind the external malleolus in a groove common to it and to the peroneus brevis, and is reflected forwards and downwards to the outer side of the os calcis, upon which it is held by a separate sheath. Having reached the outer side of the cuboid bone it is again reflected, enters a groove running obliquely inwards and forwards upon the lower surface of that bone (*e, figs.* 132, 133.), where it is retained by a very strong and compact sheath, and continues its oblique course without any deviation, along the lower surface of the tarsal bones as far as the posterior extremity of the first metatarsal bone. In this way the tendon of the peroneus longus undergoes a double reflection, first, behind the external malleolus, in which situation a thickening or knot is often seen, and secondly at the cuboid bone, opposite which a sesamoid bone almost always exists. There are also three fibrous sheaths, and three synovial membranes belonging to this tendon, one behind the external malleolus, one upon the outside of the os calcis, and a third under the cuboid bone.

Relations. In the leg, the peroneus longus is covered by the skin and the fascia of the leg: it covers the peroneus brevis. In front, a tendinous septum intervenes between it and the extensor longus digitorum: behind, another intermuscular septum exists between it and the soleus above, and the flexor proprius below. On the outside of the foot, its tendon corresponds to the skin externally, and to the os calcis internally. In the plantar region, it is covered below by the entire thickness of the soft parts, and corresponds above to the inferior tarsal ligaments.

Action. As we have already so frequently observed, a reflected muscle acts as if the power were applied at the point of reflection. In this way, by transferring the power to the outer end of the groove on the cuboid bone, we shall find that the foot is abducted, or rather rotated outwards by this muscle; by

next supposing the power to act from the other point of reflection, *i. e.* from behind the external malleolus, we may observe that the foot is extended upon the leg, and its outer border turned upwards. In this movement the lower end of the external articular surface of the astragalus tends to carry the external malleolus outwards, and to increase the curvature of the fibula, which is sometimes fractured in consequence. It may be easily conceived that if the fibula be fractured, the contraction of this muscle will no longer be counteracted, and accordingly will turn the sole of the foot outwards, and may luxate the astragalus inwards. This is the mechanism of luxation of the foot occurring after fracture of the fibula, the only species of lateral dislocation of this part which has ever been observed.*

The Peroneus Brevis.

The peroneus brevis of *Albinus* (peroneus secundus, *Spigel;* le petit péronier, *Winslow, f, figs.* 129, 130.), is a flat, penniform, and reflected muscle, smaller and shorter than the preceding, beneath which it lies.

Attachments. It *arises* from the lower half, sometimes from the lower two thirds of the external surface of the fibula, which is more or less excavated for this purpose; from the anterior and posterior borders of the same bone, and from the tendinous septa existing between this muscle and those of the anterior and posterior regions of the leg.

It is *inserted* into the posterior extremity of the fifth metatarsal bone, and sometimes even by a tendinous expansion into the fourth metatarsal bone; it often gives off a prolongation to the extensor tendon of the little toe.

The fleshy fibres proceed successively from their different origins to the internal surface and edges of a tendon, situated upon the outer surface of the muscle; the bundle which they form gradually increases in size, and then diminishes, is at first penniform and afterwards semi-penniform, and accompanies the tendon as far as the fibrous sheath behind the external malleolus: after leaving the sheath, the tendon enters another proper to itself, upon the outer side of the os calcis, above that for the tendon of the peroneus longus, and passes somewhat obliquely downwards and forwards, to be inserted into the base of the fifth metatarsal bone.

Relations. It is covered by the peroneus longus, and covers the fibula and the outer side of the os calcis. It is, therefore, only in comparison with the peroneus longus, that Riolanus and others have called this muscle the *anterior* peroneus.

Action. The same as that of the peroneus longus, with the exception of that of its subtarsal portion. Thus, supposing the power to be applied at the external malleolus, we have extension of the fifth metatarsal bone upon the cuboid; extension and rotation inwards of the second row of the tarsus upon the first; rotation of the calcaneum upon the astragalus; extension, and a tendency to abduction of the entire foot, which is therefore considerably everted when the fibula is fractured.

Posterior Region.

There are two layers in this region, one superficial, formed by the gastrocnemius and soleus (or triceps suralis) and the plantaris; the other deep, consisting of the popliteus, the tibialis posticus, the flexor longus digitorum, and the flexor longus pollicis.

The Gastrocnemius and Soleus, or Triceps Suralis, and the Plantaris.

Dissection. Make a vertical incision from the upper part of the popliteal space to the heel; at right angles to this, above, make another horizontal and

* See the admirable memoir by M. Dupuytren, on fracture of the fibula.

semi-circular incision, embracing the back part of the thigh; divide and dissect the fascia of the leg. The gastrocnemii will then be exposed, and must be dissected very carefully at their origins. In order to study the structure and attachments of these muscles properly, they must be cut transversely in the middle, and the superior half turned upwards. In dividing the outer head of the gastrocnemius, be careful not to cut the plantaris, which seems to be merely a small fasciculus detached from that muscle. The soleus is exposed by simply removing the gastrocnemius; but, in order to study its structure and attachments, it must be divided vertically from behind forwards at the side of a median tendinous raphé, and the fibres which conceal this median aponeurotic lamina of the muscle must be scraped away. From this division we have a fibular and a tibial portion of the soleus.

The gastrocnemius (*g g'*) and the soleus (*i i'*, *fig.* 129) together constitute a very powerful triceps muscle (musculus suræ, *Sœm.*), which by itself forms the fleshy part of the leg, commonly called the calf. The great developement of these muscles is one of the most marked characteristics of the muscular apparatus of the human subject, and is connected with his destination for the erect position. The three portions of the *triceps suralis* are united together below in a common tendinous insertion, constituting the *tendo Achillis* (*t*, *fig.* 129.), but are divided above into two very distinct planes: one, anterior or deep, formed by the soleus; the other, posterior or superficial, consisting of the two heads of the gastrocnemius. We shall describe these in succession.

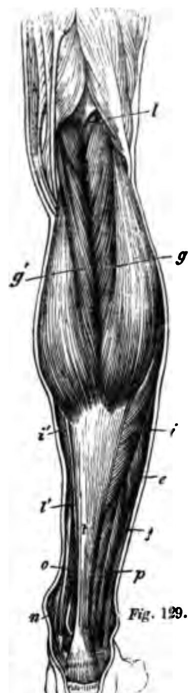


Fig. 129.

Gastrocnemius.

The *gastrocnemius*, from γαστὴρ, a belly, and κνήμη the leg (gemellus, *Albinus;* primus pedem moventium, cum secundo, *Vesalius*), is the most superficial muscle on the back of the leg: it consists of two heads above (*g g'*, *fig.* 129.), but forms a single fleshy belly, which is thick and flattened from before backwards.

It *arises* from the condyle of the femur by two perfectly distinct but similar heads, viz. an outer or smaller, called the gemellus externus (*g*), and an inner or larger, named the gemellus internus (*g'*). They take their origin from the bone by two very strong and flat tendons, which are attached on the outer side and behind the condyle of the femur to two well-marked digital impressions, that for the outer head being situated above a much deeper impression for the popliteus muscle, and that for the inner head immediately behind the tubercle into which the adductor magnus is inserted, so that the inner head is situated upon a plane a little posterior to that of the outer head. They also arise by tendinous fasciculi from the rough triangular surfaces surrounding the digital impression, and terminating at the inferior bifurcation of the linea aspera. Each tendon of origin (that for the inner being much larger than that for the outer head) expands into an aponeurosis upon the posterior surface of that portion of the muscle to which it belongs. The aponeurotic expansion of the inner head is, moreover, thicker and longer than the other, and embraces the inner border of that part of the muscle, like a tendinous semi-cone. The fleshy fibres arise from the anterior surface of these tendinous expansions, and are disposed in the following manner: those in the middle, which are few in number, are strengthened by fleshy fibres proceeding from the

rough projections of the bifurcation of the linea aspera, pass inwards and downwards, and are united together like the limbs of the letter V opening upwards, upon a median raphé, which consists either of a simple thickening of the terminating aponeurosis, or of a small tendinous septum: the other fibres, constituting almost the entire muscle, arise from the anterior surface of the tendons of origin, and from the aponeurosis in which they terminate, and proceed vertically downwards to the back of another very dense aponeurotic expansion, which covers the whole anterior surface of the muscle. This last aponeurosis commences above by two very distinct portions; at first it is of equal breadth with the muscle, then becomes narrower and thickened, and finally closely united with the terminal tendon of the soleus. At the lower part of the calf the fleshy fibres terminate suddenly upon the posterior surface of this aponeurosis, forming a V opening downwards. Although the two portions of the gastrocnemius become intimately united shortly after their origin, they are not confounded together, and the internal portion forms on the inside of the tibia the greatest part of the fleshy mass called the calf of the leg.

Relations. The gastrocnemius is covered by the fascia of the leg, and it covers and adheres intimately to the capsular ligament, which envelops the back part of the condyles of the femur. It is also in relation with the popliteus and the soleus.

The tendon of the inner head corresponds to the posterior surface of the internal condyle; that of the outer head to the outer side of the external condyle. We often find at the upper part of the tendon of each head, but most commonly in the substance of that of the outer head, a sesamoid bone, that glides upon the back of the condyle, and belongs to the sort of fibrous capsule or hood, by which the back of each condyle is covered. (Vide SYNDESMOLOGY, Articulation of the Knee.)

The Plantaris.

This little muscle (le plantaire grêle, *l l'*, *fig.* 129.), should be regarded as an accessory of the outer head of the gastrocnemius, or rather as a rudimentary muscle in the human subject. Its small fusiform fleshy belly, varying much in size, is found beneath the outer head of the gastrocnemius.

It *arises* (*l*) from the fibrous capsule covering the external condyle, and sometimes from the lower part of the external bifurcation of the linea aspera. From these points, it passes obliquely downwards and inwards; and after a course of from two inches and a half to three inches, ends in a long, flat, and slender tendon, which is at first situated between the gastrocnemius and soleus, and afterwards (*l'*) lies parallel with the inner edge of the tendo Achillis, and is *inserted* into the os calcis, either at the side, or in front of that tendon. Sometimes, however, it is lost in the subcutaneous adipose tissue. This muscle, which is often wanting, is occasionally double.*

The Soleus.

The *soleus* (partly seen at *i i'*, *fig.* 129.) is so called, because it has been compared to the fish called a sole, or to the sole of a shoe.

Attachments. It *arises* from the fibula and tibia, and is *inserted* into the os calcis. Its *fibular origins* (*i*) consist first of a tendon attached behind, and on the inner side of the head of that bone; this tendon is extremely strong, especially on the inside, opposite a process existing on the fibula for its attachment; it is prolonged within the substance, and along the anterior surface of the muscle: and secondly, of some tendinous fibres attached to the upper half

* Fourcroy, in his sixth memoir upon the bursæ mucosæ, states that the plantaris, whose tendon, according to Albinus, is received into a groove, along the inner border of the tendo Achillis, is the tensor muscle of the synovial capsule of that tendon. This is an error.

of the external border of the fibula, and the upper third of the posterior surface of the same bone.

The *tibial origins* (*i'*) take place from the oblique line on the posterior surface of the tibia below the popliteus, and from the contiguous portion of the aponeurotic expansion of that muscle; from an aponeurosis which arises from the middle third of the inner border of the tibia, and is prolonged upon the anterior surface, within the substance of the muscle; and lastly, by a few fleshy fibres from a tendinous arch extending between the head of the fibula and the oblique line on the posterior surface of the tibia. From these different origins, the fleshy fibres pass in different directions to the anterior surface and edge of an aponeurosis, which covers the posterior surface of the muscle, becomes narrower and thickened as it proceeds downwards, unites with the terminal tendon of the gastrocnemius about the middle third of the leg, and is soon blended with it to form the tendo Achillis.

In order to study accurately the structure of the soleus, divide it longitudinally at the side of the raphé or tendinous septum, existing in the middle of the lower half of this muscle, and then by scraping off some of the fleshy fibres, it will be seen, that a dense fibrous septum given off by the terminal aponeurosis, separates the muscle into two equal halves, and forms with that aponeurosis two tendinous semi-cones, in the interior of which the fleshy fibres are received. It will now be understood why Douglas, who had designated the gastrocnemius the two external and superficial heads of the *great extensor* of the tarsus, should call the soleus the two internal and deep heads of the same muscle. There are, in fact, two principal aponeuroses of origin, and two hollow tendons of insertion; each aponeurosis of origin covers almost the entire anterior surface of the corresponding half of the muscle.

Relations. It is covered by the gastrocnemius, which projects beyond it on both sides, but especially on the inner side, and from which it is separated by the plantaris. It is thickest immediately below the largest part or belly of the inner portion of the gastrocnemius, and consequently it prolongs the swelling of the calf downwards. It covers the muscles of the deep layer, viz. the flexor communis digitorum, the flexor proprius pollicis, and the tibialis posticus; it also covers the posterior tibial and the fibular vessels and nerves.

The tendo Achillis. The tendo Achillis (*l*, *figs.* 129, 130.) results from the union of the tendons of the gastrocnemius, plantaris, and soleus. It is formed in the following manner: the terminal aponeurosis of the gastrocnemius, shortly after leaving the fleshy fibres, is intimately united to that of the soleus, which still continues to receive fleshy fibres upon its anterior surface and its edges, and gradually becoming narrower, is soon joined by the antero-posterior septum of this muscle. All these tendinous fibres are collected together to form the strongest and largest tendon in the body, known by the name of the *tendo Achillis*, which after a course of about an inch and a half or two inches, glides over the smooth surface presented by the superior two thirds of the back of the os calcis, with the intervention of a synovial bursa, and is expanded a little in order to be inserted into the rough surface on the lower part of the same bone.

Action of the gastrocnemius and soleus. These muscles extend the foot upon the leg. In no other part of the body do we find so advantageous an arrangement for an immense developement of power. 1. These muscles are very large, and particularly remarkable for the number of their fleshy fibres, in which respect they exceed all other muscles in the body. 2. The mode of insertion is no where else so favourable; for it is absolutely perpendicular. 3. We have here a lever of the second order, in which the fulcrum is at the ball of the toes, the resistance in the middle of the foot, being represented by the weight of the body resting upon the ankle joint, and the power at the extremity of the heel (see *fig.* 104.). The length of that portion of the lever which projects behind the joint, varies much in different individuals; it scarcely exists in the peculiar mal-formation denominated *flat-foot.* These

nuscles are the principal agents in walking and leaping; they raise the weight ›f the whole body, even when loaded with heavy burdens. Hence it is not ›urprising, that occasionally an energetic contraction of these muscles may ·upture the tendo Achillis, or fracture the os calcis. Frequent exercise ap- ›ears to be necessary for these muscles; for when they remain inactive, they ›ecome atrophied, and are speedily affected with fatty degeneration. The ›ction of the soleus, which reaches only from the leg to the heel, is limited to ›xtension of the foot; but the gastrocnemius, which is attached to the femur, ›fter having extended the foot, can flex the leg upon the thigh; but from its ›roximity to the fulcrum, this last action is very slight. When the foot is ixed, as for example in standing, the soleus acts upon the leg, and tends to ›revent one from falling forwards, to which there is a constant tendency from he weight of the body; the action of the gastrocnemius, on the contrary, is to lex the thigh, and in this respect it is altogether independent of the soleus.

The plantaris can only be regarded as rudimentary in man; in the lower ›nimals it is a tensor of the plantar fascia; it has been, as it were, cut short in ›nan, in consequence of his destination for the erect position. Sometimes, as we have already stated, it is lost upon the fatty tissue covering the os calcis.

The Popliteus.

This is a small triangular and very thin muscle (*m*, *fig.* 130.), situated in the popliteal space.

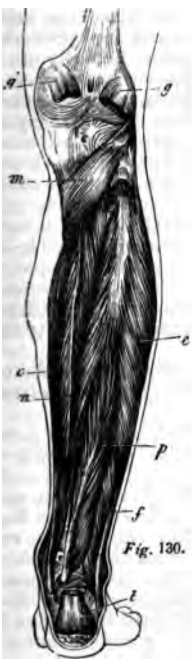


Fig. 130.

It *arises* from a deep fossa, resembling a groove running from behind forwards, on the back of the external condyle of the femur, below the origin of the outer head of the gastrocnemius. It is *inserted* into the entire extent of the triangular surface on the upper part of the posterior aspect of the tibia.

It arises by a very strong tendon, which bears no proportion to the diminutive size of the muscle. This tendon, at first concealed by the external lateral ligament, contained as it were in the cavity of the joint, and completely enveloped by the synovial membrane, passes obliquely behind the articulation, and after extending for about one inch, divides, like the tendon of the obturator internus, into four or five small diverging bundles, which soon surround the fleshy fibres on all sides. The latter then become attached in succession to the triangular surface of the tibia, the lowest being the longest and the most oblique. The superficial fibres are inserted into a tendinous expansion from the semimembranosus, which covers the posterior surface of the popliteus muscle, and forms a very strong sheath for it.

Relations. It is covered by the gastrocnemius and the plantaris, from which it is separated by the popliteal vessels, and the internal popliteal branch of the sciatic nerve. It covers the tibio-fibular articulations and the back of the tibia.

Action. It flexes the leg upon the thigh, and at the same time rotates it inwards (oblique movens tibiam. *Spigelius*). In this last respect, it antagonises the biceps.

The Tibialis Posticus.

Dissection. Remove the gastrocnemius and soleus; separate the tibialis posticus from the flexor longus digitorum, which partially covers it; carefully remove from the posterior surface of the tibialis posticus a very broad apo-

neurosis together with a portion of the long flexor of the toes, which arises from the posterior surface of that aponeurosis; completely separate the tibialis posticus from the interosseous ligament, and the adjacent portions of the tibia and fibula; lastly, be careful to preserve the tendinous expansions always given off by this muscle to the fourth and fifth metatarsal bones.

The *tibialis posticus* (*n*, *fig.* 130.) is the most deeply seated of all the muscles on the back of the leg; it is very thick, and occupies the whole depth of the excavation between the tibia, fibula, and interosseous ligament.

Attachments. It *arises* from the tibia, the fibula, and the interosseous ligament, and is *inserted* into the scaphoid bone. Its tibial and fibular origins form a bifurcation for the passage of the posterior tibial artery. Its tibial attachment takes place on the oblique line situated below the popliteus, soleus, and flexor longus digitorum. Its fibular origin is from the inner border of that bone, below the soleus, and from all that portion of its inner surface, which is behind the interosseous ligament. It also arises from the entire posterior surface of this ligament. Lastly, a few fibres take their origin from the deep surface of an aponeurosis, which separates the deep from the superficial layer of muscles, and from the tendinous septa interposed between this muscle itself and the flexor longus digitorum on the inside, and the flexor proprius pollicis on the outside. From these numerous origins the fleshy fibres proceed vertically downwards, around a tendon which may be distinguished near the upper extremity of the muscle under the form of a tendinous sheaf, which afterwards appears along its posterior border, and receives the fleshy fibres on its anterior surface, like the barbs of a feather upon the shaft. This tendon, however, is nothing more than the thickened posterior edge of an aponeurosis occupying the entire substance of the muscle from before backwards, and receiving the fleshy fibres upon its two lateral surfaces as far down as opposite the internal malleolus. The thick tendon resulting from the union of these aponeurotic fibres then becomes free and enters a proper sheath on the outer side of that belonging to the tendon of the flexor longus digitorum, in front of which it then passes behind the internal malleolus, where it is also inclosed in a separate sheath (*n*, *fig.* 129.). On the inner side of the internal lateral ligament of the ankle and below the lower calcaneo-scaphoid ligament it enters another sheath, and is finally inserted (*n*, *fig.* 133.) into the tubercle of the scaphoid bone, a very thick sesamoid bone existing near its insertion. In some subjects this sesamoid bone is found at the point of insertion; in others it is situated opposite the calcaneo-scaphoid ligament. Besides this the tendon of the tibialis posticus gives off a very strong expansion to the first cuneiform bone, and on the outside an oblique expansion to the second and third cuneiform bones, and even to the third or fourth metatarsal bones.

Relations. It is covered by the flexor longus digitorum, slightly by the flexor proprius pollicis, and entirely by the soleus: it covers the interosseous ligament and the adjacent parts of the tibia and fibula.

Action. The tibialis posticus extends the foot upon the leg. As it is a reflected muscle, all the fibres must be considered as acting from the point of reflection that is behind the inner ankle. It is evident, then, that this muscle extends the foot, both by its action upon the astragalo-scaphoid articulation, and also by that upon the ankle joint. It also tends to turn the sole of the foot inwards; and, consequently, it cooperates with the tibialis anticus in this respect, and antagonises the peroneus longus and brevis. It may also be understood why some persons, in whom the tendo Achillis has been cut or ruptured, are yet capable of walking, and why the foot can in all cases be extended after this accident: but under these circumstances the lever formed by the foot is changed, and the power represented by the tibialis posticus is applied between the fulcrum and the resistance; so that we have then a lever of the third, not of the second order, as when the tendo Achillis is uninjured.

The Flexor Longus Digitorum Pedis.

This is a penniform, elongated, and reflected muscle (*o, figs.* 130. 132.), situated along the posterior surface of the tibia and in the sole of the foot; it is the most internal muscle of the deep layer, is flattened from before backwards, and terminates below in four tendons.

Attachments. It *arises* from the tibia, and is *inserted* into the last phalanges of the last four toes. It arises from the oblique line of the tibia, below the popliteus and the soleus, and from the middle three fifths of the posterior surface of the same bone. Some fibres also proceed from the tendinous septum intervening between it and the tibialis posticus. From these different origins the fleshy fibres proceed obliquely backwards and downwards to the anterior surface and edges of a tendon, which commences near the upper end of the muscle, and gradually disengages itself from the fleshy fibres, being accompanied by them anteriorly as far as the internal malleolus. It passes behind this projection in the same sheath as the tendon of the tibialis posticus, from which it is separated by a fibrous septum; it soon leaves that tendon, passing to its outer or fibular side (*o, fig.* 129.), and is then reflected at an obtuse angle upon the internal malleolus. It now becomes horizontal, and is buried under the astragalus and the small anterior tubercle of the os calcis, where it is contained in a proper sheath. Having thus reached the sole of the foot (*o, figs.* 131, 132.) it passes obliquely outwards and forwards, crosses *under* the tendon of the flexor longus pollicis at a very acute angle, receives from it a strong tendinous communication, and at the same time becoming expanded is joined by its accessory muscle, and finally divides into four tendons for the last four toes. The tendon for the second toe proceeds directly forwards. The tendons for the other toes in succession pass more and more obliquely. Having reached the metatarso-phalangal articulations these tendons are received, together with those of the flexor brevis digitorum, into the sheaths upon the first and second phalanges; and they have precisely the same relations to the tendons of the last mentioned muscle, as the flexor profundus is observed to have with regard to the flexor sublimis digitorum in the hand; and hence the name of *perforans* given by Spigelius to the long flexor of the toes. The tendons are finally inserted into the posterior extremities of the third phalanges. The tendinous parts of this muscle are lubricated by synovial membranes where they pass through the different sheaths.

Relations. It is covered by the soleus, the posterior tibial vessels and nerves, and it covers the tibia and the tibialis posticus. In the foot, it is covered below by the flexor brevis digitorum, and the adductor pollicis.

Action. It flexes the third phalanges upon the second, the second upon the first, and the first upon the corresponding metatarsal bones. When these movements have been accomplished, it extends the foot upon the leg. From the obliquity of its reflected portion, it would turn the toes and the sole of the foot slightly inwards, if the accessory muscle did not as it were rectify its action, as well as cooperate with it. In standing it opposes flexion of the leg forwards.

The Flexor Longus Pollicis.

The *flexor longus pollicis* is the most external and the largest muscle in the deep region of the leg: it is prismatic and quadrangular, vertical and fleshy in the leg (*p, figs,* 129, 130.), tendinous and horizontal in the foot (*p, figs.* 131, 132.).

Attachments. It *arises* from the fibula, and is *inserted* into the last phalanx of the great toe. Some of the fibres arise directly from the inferior two thirds, and from the internal and external borders of the fibula; others arise from the fascia covering the tibialis posticus (its origin from the fibula, and that

from the fascia of the tibialis muscle, are separated from each other by the peroneal vessels); from a tendinous septum between it and the peroneus longus and brevis; and from a small portion of the lower part of the interosseous ligament. From these numerous points of origin, the fleshy fibres pass obliquely downwards and backwards, around a tendon which occupies the entire length of the muscle, and may be seen at the lower part of the leg, through a thin layer of muscular fibres. These fibres terminate abruptly behind the ankle joint, at the oblique groove on the astragalus, in which the tendon is lodged; it then turns into a groove on the os calcis, forming a continuation of the preceding (*fig.* 133.), and situated below that for the tendon of the flexor longus digitorum, and dips into the sole of the foot. It is retained in these two grooves, which run obliquely downwards, inwards, and forwards, by a very strong and continuous sheath (*fig.* 132.). In the sole of the foot, the tendon is deeply situated (*p*, *fig.* 131.), passes forwards, and crosses (*p*, *fig.* 132.) at an acute angle above the tendon of the flexor longus digitorum, to which it gives off a considerable fibrous prolongation. It is then received in a groove formed between the flexor brevis digitorum, and the oblique adductor of the great toe, passes below the anterior glenoid ligament of the metatarso-phalangal articulation of that toe, between the two sesamoid bones, and is received into the osteo-fibrous sheath of the first phalanx, to be inserted into the posterior extremity of the second.

Relations. It is covered by the soleus, being separated from it by a fascia, which increases in thickness as it passes downwards; it is also covered by the tendo Achillis; it covers the fibula, the tibialis posticus, the peroneal artery, and the lower part of the interosseous ligament. Externally, it is in relation with the peroneus longus and brevis; internally, with the flexor longus digitorum.

Action. It flexes the second phalanx of the great toe upon the first, and this upon the first metatarsal bone; having produced these movements, it then extends the foot upon the leg. From the obliquity of its fleshy belly it has a tendency to turn the great toe and the foot outwards. In this respect it antagonises the flexor longus digitorum and the tibialis posticus. The very strong tendinous expansion which unites it to the long flexor of the toes consolidates the two muscles; in fact, it is very uncommon to find either of them acting independently.

MUSCLES OF THE FOOT.

The extensor brevis digitorum. — Abductor pollicis pedis. — Flexor brevis pollicis pedis. — Adductor pollicis pedis. — Transversus pollicis pedis. — Abductor minimi digiti. — Flexor brevis minimi digiti. — Flexor brevis digitorum. — Flexor accessorius. — Lumbricales. — Interossei.

THE muscles of the foot are divided into those of the dorsal and plantar aspects and the interossei. The muscles of the plantar aspect may be again subdivided into three regions, viz. those of the *middle plantar region*, those of the *internal plantar region*, and those of the *external plantar region*. A single muscle occupies the dorsum of the foot, viz. the extensor brevis digitorum. The muscles of the internal plantar region are four in number, viz. the abductor, the flexor brevis, and the oblique and transverse adductors of the great toe. The last two muscles may be regarded as forming part of the middle plantar region.

The muscles of the external plantar region are the abductor and the flexor brevis of the little toe.

The muscles of the middle region are the flexor brevis digitorum, the flexor accessorius, and the lumbricales.

The interosseous muscles are seven in number, and are divided into the dorsal and plantar.

Dorsal Region.

The Extensor Brevis Digitorum.

Dissection. Remove the dorsal fascia of the foot, and the tendons of the muscles of the anterior region of the leg.

The *extensor brevis digitorum* (*q, fig.* 128.) is a thin, flat, quadrilateral muscle, situated on the dorsum of the foot; it is divided into four portions anteriorly, and is an accessory of the extensor longus digitorum. It *arises* from the os calcis, and is *inserted* into the first four toes.

It arises, by a rounded extremity, from a small excavation on the outside of the foot, formed by the os calcis and the astragalus (*the astragalo-calcanean fossa*), and from the os calcis in front of that excavation. Its origin from these parts is both fleshy and tendinous. The muscle then passes forwards and inwards, and soon divides into four fleshy fasciculi, each representing a little penniform muscle, and terminating quickly in a small tendon, the size of which is proportioned to the strength of the fasciculus. The internal tendon is the largest, because it is intended for the great toe; it is situated below the tendon of the extensor proprius pollicis, which it crosses at a very acute angle, and is inserted into the dorsal surface of the proximal end of the last phalanx. The second, third, and fourth tendons, intended for the second, third, and fourth toes, are subjacent to the corresponding tendons of the extensor longus digitorum, which they cross at a very acute angle. Having reached the metatarso-phalangal articulations, the tendons of the short extensor are situated to the outside of those of the extensor longus, and are blended with them, so as to complete the fibrous sheath on the dorsal surface of the first phalanx, and to terminate in a similar manner.

Relations. It is covered by the dorsal fascia of the foot, by the tendons of the extensor longus digitorum and extensor proprius pollicis; it covers the second row of the tarsal bones, the metatarsus, and a small portion of the interosseous muscles, and the phalanges. The arteria dorsalis pedis runs at first along the inner border of this muscle, which overlaps the artery, where the latter perforates the first interosseous space, in order to reach the sole of the foot.

Action. It extends the first four toes; it acts upon the first phalanx only of the great toe. Its obliquity enables it to correct the contrary oblique movement communicated to the toes by the contraction of the extensor longus digitorum; so that the opposite actions of these two muscles are mutually destroyed, and the foot is extended directly. Not uncommonly, the extensor brevis presents a fifth fasciculus, which is lost upon some one of the metatarso-phalangal articulations.

Internal Plantar Region.

The muscles of the ball of the great toe may be divided, like those of the thumb, into two orders, viz. those which pass from the tarsus to the inner side of the first phalanx, and those which pass from the tarsus to the outer side of the same phalanx. Here, as with the muscles of the thumb, the tendon of the flexor longus divides the flexor brevis pollicis pedis of authors into two parts,—one internal, forming the flexor brevis of the great toe, properly so called; the other external, which is found to be connected with the oblique adductor of this toe.

Muscles inserted into the inner Side of the First Phalanx of the Great Toe.

Dissection. In order to expose the abductor brevis, it is sufficient to remove the internal plantar fascia; the flexor brevis will be found under, *i. e.* deeper than the tendon of the abductor brevis.

The muscles inserted into the inner side of the first phalanx of the great toe, are the abductor brevis and the flexor brevis. They are distinct at their origins, but are often blended at their insertions; so that Winslow united them together under the name of *le thénar du pied.*

The Abductor Pollicis Pedis.

This muscle (le court adducteur,* *Cruveilhier, r, fig.* 131.) is the most superficial in the internal plantar region; it *arises* on the inside, from the internal posterior tuberosity of the os calcis; from the internal annular ligament under which the posterior tibial vessels and nerves pass; from the upper surface of the internal plantar fascia; and from the lower surface of a tendinous expansion, which occupies the entire extent of the deep or superior surface of the muscle. From these points, the fleshy fibres proceed to the circumference of a tendon (*r, figs.* 132, 133.), which emerges from them inferiorly near the first cuneiform bone, but is often accompanied by them superiorly as far as its *insertion* into the internal sesamoid bone, opposite the first phalanx of the great toe.


Fig. 131.

Relations. It is covered below by the internal plantar fascia, and is divided from the muscles of the middle plantar region by a tendinous septum which gives attachment to some of its fleshy fibres. It is superficial to the flexor brevis pollicis, the flexor accessorius, the tendons of the flexor longus digitorum and that of the flexor longus pollicis, the tarsal insertions of the tibialis anticus and posticus, the plantar vessels and nerves, and the internal articulations of the tarsus.

Action. It is, properly speaking, a flexor of the great toe.

The Flexor Brevis Pollicis Pedis.

Adopting a similar plan in the definition of this muscle as in that of the short flexor of the thumb, I shall describe as the short flexor of the great toe, that portion (*s, fig.* 133.) only of the flexor brevis of authors, which extends from the second row of the tarsus to the internal sesamoid bone of the metatarso-phalangal articulation of the great toe, and shall refer to the oblique adductor that portion (*t*) which is attached to the external sesamoid bone. This change appears to be warranted by the rule already laid down for the distinction of muscles. Community of the fixed points of origin is not sufficient to establish the unity of two muscles, provided their moveable insertions are distinct. A cellular interval and the tendon of the flexor longus pollicis establish anteriorly the line of demarcation between the flexor brevis and the adductor obliquus pollicis.

According to this view, the flexor brevis pollicis (*s, figs.* 131, 132, 133.) *arises* from the second row of the tarsus, particularly from the cuboid and the third cuneiform bones, by some tendinous fibres which are formed by a continuation of the inferior ligaments of the tarsus, and are common to this muscle and the internal portion (*t*) of the oblique adductor of the great toe. The tendon of the tibialis posticus (*n, fig.* 133.), or rather the prolongation which this tendon gives off to the fourth metatarsal bone, also furnishes some points of origin. The fleshy fibres proceeding from these different attachments form

* See note, next page.

a bundle that gradually increases in size, becomes separated from the oblique adductor, and terminates in a tendon which is *inserted* into the external sesamoid bone and also into the glenoid ligament of the metatarso-phalangal articulation. Not unfrequently the greater number of the fleshy fibres are attached to the tendon of the abductor brevis, and thus constitute the short head of a biceps muscle.

Relations. The flexor brevis pollicis is in relation below with the internal plantar fascia, and with the tendon of the abductor brevis pollicis, being moulded upon it, and usually separated from it by a tendinous sheath, except in those cases where the two muscles are blended together. Observe that at the point where the fleshy belly of the abductor terminates, the flexor brevis is in relation above with the tendon of the peroneus longus (*e*, *fig.* 133.) and the first metatarsal bone.

Action. The same as that of the preceding muscle, but it is much less powerful and less extensive.

Muscles inserted into the External Side of the First Phalanx of the Great Toe.

These are the oblique and transverse adductors.*

Dissection. They are exposed by cutting across, and turning forwards the flexor brevis digitorum, the tendons of the flexor longus digitorum, and the flexor accessorius: particular care should be taken, when the dissection has extended as far as the heads of the metatarsal bones, to avoid cutting the small transverse adductor.

The Adductor Pollicis Pedis.

This (l'abducteur oblique, *Cruveilhier*, *t t'*, *fig.* 133.) is the largest of all the plantar muscles; it is prismatic and triangular, and occupies the great hollow formed by the last four metatarsal bones, and is bounded by the first metatarsal bone on the inner side. It extends from the second row of the tarsus to the external sesamoid bone of the great toe. It *arises* by two very distinct portions, the smaller (*t*, *figs.* 131, 132, 133.), common to it and to the flexor brevis, proceeds from the cuboid bone; the other (t') is much larger and arises from the sheath of the tendon of the peroneus longus (*e*), from the posterior extremities of the third, fourth, and fifth metatarsal bones, and from the transverse ligaments by which they are united. From these different origins the fleshy fibres pass more or less obliquely inwards, and are *inserted* by a tendinous bundle into the external sesamoid bone of the metatarso-phalangal articulation of the great toe, and into the posterior edge of the glenoid ligament of the same joint.

Relations. Its inferior surface is in relation with the long and short flexors of the toes, with the flexor accessorius, the lumbricales, and the plantar fascia; its *superior surface*, with the interosseous muscles and the external plantar

* [The terms adductor and abductor are applied by M. Cruveilhier to the muscles of the great toe, from their respective actions upon it, in reference to the axis of the body; the muscle attached to the inner side of that toe being called its adductor, and those to the outer side its abductors. In the translation, however, the nomenclature of Albinus has been adopted, in which the terms adductor and abductor have reference to the *axis of the limb*; first, because it is followed by the majority of authors, and, secondly, because it is in accordance with the principle observed by M. Cruveilhier himself, in describing not only all the muscles of the hand, but some even of those of the foot, viz. the interossei, which are classed by him as abductors or adductors, according as they draw the several toes from or towards an imaginary axis passing through the *second* toe. By this change much risk of perplexity will be avoided, and a uniform principle of nomenclature preserved as regards all the muscles of the hand and foot.

In the description of each muscle of the great toe, the synonymes of Cruveilhier are given between brackets; but in all instances, both here and hereafter, where these muscles have incidentally to be mentioned, the names adopted from Albinus will be strictly adhered to.

It is scarcely necessary to observe that the *abductor* of the little toe will still retain its name.]

artery; and its *inner surface* with the first metatarsal bone, the tendon of the peroneus longus, and with the flexor brevis pollicis.

Action. It is a powerful adductor and flexor of the great toe.

The Transversus Pollicis Pedis.

This small transverse bundle (l'abducteur transverse, *Cruveilhier*, *u*, *fig.* 133) forms an appendage of the preceding muscle, and is represented in the hand by the transverse fibres of the adductor pollicis; it extends from the fifth metatarsal bone to the external sesamoid bone of the metatarso-phalangal articulation of the great toe.

This muscle, which is of variable size, *arises* externally from beneath the head of the fifth metatarsal bone, by a tendinous and fleshy tongue, which is directed transversely inwards, is strengthened by other fibres arising from the anterior transverse ligament of the metatarsus, and from the interosseous aponeurosis, and is *inserted* into the outer side of the first phalanx of the great toe, where it is often blended with the attachment of the oblique adductor.

Relations. It is in relation below with the tendons of the long and short flexors of the toes and with the lumbricalis, and above with the interosseous muscles. It is lodged in the anterior part of the deep concavity of the metatarsus, and is provided with a proper sheath.

Actions. It adducts the great toe, and draws the head of the metatarsal bones towards each other.

External Plantar Region.

The Abductor Digiti Minimi.

Dissection. This is common to the abductor and the flexor brevis. The first is exposed by simply removing the external plantar fascia, and the second by removing or reflecting down the first.

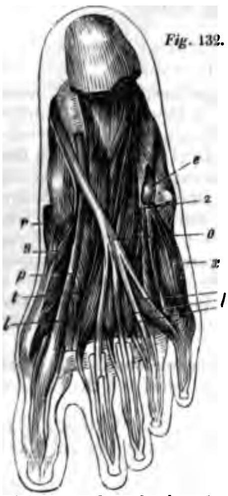
The *abductor digiti minimi* (*v*, *fig.* 131.) is of the same form, the same structure, and almost the same size as the abductor pollicis, and extends from the os calcis to the first phalanx of the litttle toe. It *arises* by tendinous and fleshy fibres from the external posterior tuberosity of the os calcis, from the outer side of the internal posterior tuberosity, and from an aponeurosis occupying the upper surface of the muscle. The fleshy fibres having arisen in succession from these different points, proceed obliquely round a tendon, from which they emerge, opposite the posterior extremity of the fifth metatarsal bone. The fleshy belly of the muscle appears to end at this point, but it is continued by other fibres, arising from the upper surface of the external plantar fascia, and inserted either into the common tendon, or separately by the side of this tendon into the outer part of the first phalanx of the little toe. A small fleshy bundle is frequently detached from the body of the muscle, and implanted into the posterior extremity of the fifth metatarsal bone, together with a prolongation of the external plantar fascia, which serves as a tendon for it.

Action. It is an abductor and flexor of the little toe.

The Flexor Brevis Digiti Minimi.

This is a small fleshy fasciculus (*x*, *figs.* 131, 132, 133.), situated along the external border of the fifth metatarsal bone, and forming a continuation of the series of interosseous muscles, with which it was for a long time confounded (interosseus, *Spigelius*): it extends from the second row of the tarsus, and from the fifth metatarsal bone, to the first phalanx of the little toe. It *arises* from the ligamentous layer covering the plantar surface of the metatarsal row of the tarsal bones, and from the posterior extremity of the fifth metatarsal bone; it is *inserted* into the outer side of the first phalanx of the little toe, or, more correctly, into the posterior edge of the glenoid ligament of the metatarso-phalangal articulation of that toe. Some of the fleshy fibres will be found attached to the entire length of the external border of the fifth metatarsal bone; and these sometimes form a small and very distinct muscle, representing the opponens digiti minimi of the hand.

Fig. 132.



Relations. It is covered below by the plantar fascia, which is here very thin, and also by the tendon of the abductor digiti minimi; it is in relation above with the fifth metatarsal bone and the first plantar interosseous muscle.

Action. The same as that of the preceding muscle with regard to flexion, but its action is less powerful and less extensive.

Middle Plantar Region.

The Flexor Brevis Digitorum.

Dissection. Remove the plantar fascia, which is intimately united to this muscle posteriorly.

The flexor brevis digitorum (*y*, *fig.* 131.) is a short thick muscle, narrow behind, and divided into four tendons in front. It *arises* from the inside of the external tuberosity of the os calcis, from the upper surface of the middle plantar fascia, from a special tendinous expansion occupying the lower surface of the muscle, and appearing to be a dependence of the plantar fascia; and, lastly, from an aponeurotic septum, situated between it and the muscles of the external plantar region. It forms a fleshy belly, which is narrow and thick behind, passes directly forwards, increases in breadth, and soon divides into four, sometimes only into three fasciculi, constituting as many small and perfectly distinct penniform muscles, the long and delicate tendons of which emerge from the fleshy fibres before reaching the metatarso-phalangal articulations, become flattened, and are then situated below and in the same sheath with the tendons of the flexor longus. Opposite the first phalanx each tendon of the short flexor bifurcates, to allow the passage of the corresponding tendon of the flexor longus, is formed into a groove, becomes re-united above the latter tendon, and once more bifurcates, in order to be *inserted* along the borders of the second phalanx (hence it was named perforatus by *Spigelius*, and le perforé du pied by *Winslow*). The short flexor of the toes is therefore analogous to the superficial flexor of the fingers.

Relations. It is covered below by the plantar fascia and the skin; it is in relation above with the plantar vessels and nerves, with the tendon of the flexor longus digitorum, and with the flexor accessorius and the lumbricales, from

which it is separated by a tendinous lamina. On its outer and inner side it is completely isolated from all the adjacent muscles by prolongations of the plantar fascia.

Action. It flexes the second phalanges of the last four toes upon the first phalanges, and these upon the corresponding metatarsal bones.

The Flexor Accessorius.

This is a flat quadrilateral muscle, forming a considerable fleshy mass (massa carnea, *Jacobi Sylvii*, *z*, *fig.* 132.); it *arises* by a bifurcated extremity from the lower part of the groove of the os calcis, and a small part of the calcaneo-scaphoid ligament by fleshy fibres, and by means of a tendon from the lower surface of the same bone, this tendon sometimes extending as far as the external posterior tuberosity of the os calcis. From these points the fleshy fibres pass directly forwards, and terminate in the following manner: the lower fibres become *inserted* into the outer margin, and a small portion of the inferior surface of the tendon of the flexor longus digitorum; whilst the upper are *inserted* into several small fibrous bundles, which unite together, receive a considerable expansion from the tendon of the flexor longus pollicis, and are ultimately blended with, and increase the size of the divided tendon of the flexor longus digitorum.

Relations. This muscle is in relation *below* with the flexor longus digitorum and the plantar vessels and nerves, and *above* with the os calcis and the inferior calcaneo-cuboid ligaments.

Action. It is a muscle of re-inforcement, and assists in flexing the toes: from its obliquity it rectifies the oblique action of the flexor longus digitorum in the opposite direction.

The Lumbricales.

The lumbricales (*l l*, *figs.* 131, 132.), which form a second class of accessory muscles belonging to the flexor longus digitorum, exactly resemble the lumbricales of the fingers; they consist of four small fleshy tongues, decreasing in size from within outwards, the two outer of which are not unfrequently atrophied: they extend from the angles formed by the division of the tendons of the flexor longus to the inner or tibial borders of the first phalanges of the last four toes, and to the corresponding margins of the extensor tendons. They are distinguished by the numerical names of *first*, *second*, *third*, and *fourth*. The first is situated parallel with the flexor tendon of the second toe.

Relations. They are covered below by the flexor brevis digitorum; they emerge from beneath the plantar fascia, in the interval between the sheaths furnished by it to the flexor tendons, gain the inner side of the corresponding metatarso-phalangal articulation, and terminate upon the first phalanx and inner margin of the tendons of the extensor longus digitorum. They have the same *action* as the lumbricales of the hand.

Interosseous Region.

The Interossei.

The interrosseous muscles of the foot correspond exactly with those of the hand, and require the same consideration.

They *arise* from the lateral surfaces of the interrosseous spaces in which they are placed; and are *inserted* into the sides of the first phalanges and the corresponding margins of the tendons of the extensor muscles. They are seven in number, viz. four dorsal (three of which are seen at *d d d*, *fig.* 133.), and three plantar (*p p p*); to the latter, however, the oblique adductor of the great toe may be added, for it is nothing more than a very large plantar interosseous muscle.

As in the hand, the dorsal interrossei are abductors, their origins being situated externally to the axis of the foot; the plantar interrossei again are adductors: but the axis of the foot must be supposed to extend through the *second*, and not through the middle toe. As we observed in the hand, the dorsal interossei project into the plantar region, by the side of the plantar muscles; and so narrow are the interrosseous spaces in the foot, that these dorsal muscles are much more completely situated in the plantar, than those of the hand in the palmar region. The plantar interossei corresponding to the fourth and fifth toes, arise not only from the lower two thirds of the internal or tibial side of the corresponding metatarsal bone, but also from the lower surface of the posterior extremity of the same bone. It follows, therefore, that the interosseous muscles, viewed from below, appear one continuous muscle, in which it would be difficult to separate the muscles of each space, if the interosseous plantar fascia did not give off prolongations between them; elsewhere, a cellular line defines the limit between each plantar and dorsal muscle.

Fig. 183.

Again, as in the hand, the dorsal interossei arise from two corresponding metatarsal bones at once, but more especially from the lateral surface of that metatarsal bone, which is directed *from* the axis of the foot: as in the hand, also, their posterior extremities are perforated by the posterior perforating arteries, the first being perforated by the arteria dorsalis pedis. The plantar interossei arise from only one of the metatarsal bones, and from the lateral surface that is directed *towards* the imaginary axis of the foot; moreover, they do not arise from the entire thickness of the bone, but only from its inferior two thirds, since the upper third is covered by the dorsal muscle.

The following are the general *relations* of the interossei: they are separated above, from the tendons of the extensors, by a layer of fibrous tissue, and by the dorsal interosseous fascia; and below from the proper muscles of the foot, by the deep plantar interosseous fascia, which is much stronger than the corresponding structure in the hand, and gives off septa between the *different pairs* of interosseous muscles.

PHYSIOLOGICAL ARRANGEMENT OF THE MUSCLES.

HOWEVER important it may be to become acquainted with the order of superimposition, or the topographical arrangement of the muscles, it is no less necessary to study the retrospective uses, in other words, the physiological arrangement of these organs.* In order to obtain as much as possible the advantages of each of these two methods, having already described each muscle in its topographical order, I shall now give a table of the muscles, arranged according to their physiological relations. It is important to observe that the terms, *muscles of the arm*, *of the thigh*, *&c.* have not the same accept-

* Custom, rather than conviction, has induced me to prefer the topographical to the physiological arrangement. The only objection which can be urged against the latter is, that it does not permit all the muscles to be dissected upon the same subject; but this objection applies only to a few regions; and as these regions exist in pairs, the superficial muscles on one side might surely be sacrificed. Moreover, there is no reason why the examination of the deep-seated muscles should not be postponed until the superficial ones have been studied. I therefore direct students to dissect these parts sometimes according to their topographical, and at others after their physiological order.

neurosis together with a portion of the long flexor of the toes, which arises from the posterior surface of that aponeurosis; completely separate the tibialis posticus from the interosseous ligament, and the adjacent portions of the tibia and fibula; lastly, be careful to preserve the tendinous expansions always given off by this muscle to the fourth and fifth metatarsal bones.

The *tibialis posticus* (*n*, *fig*. 130.) is the most deeply seated of all the muscles on the back of the leg; it is very thick, and occupies the whole depth of the excavation between the tibia, fibula, and interosseous ligament.

Attachments. It *arises* from the tibia, the fibula, and the interosseous ligament, and is *inserted* into the scaphoid bone. Its tibial and fibular origins form a bifurcation for the passage of the posterior tibial artery. Its tibial attachment takes place on the oblique line situated below the popliteus, soleus, and flexor longus digitorum. Its fibular origin is from the inner border of that bone, below the soleus, and from all that portion of its inner surface, which is behind the interosseous ligament. It also arises from the entire posterior surface of this ligament. Lastly, a few fibres take their origin from the deep surface of an aponeurosis, which separates the deep from the superficial layer of muscles, and from the tendinous septa interposed between this muscle itself and the flexor longus digitorum on the inside, and the flexor proprius pollicis on the outside. From these numerous origins the fleshy fibres proceed vertically downwards, around a tendon which may be distinguished near the upper extremity of the muscle under the form of a tendinous sheaf, which afterwards appears along its posterior border, and receives the fleshy fibres on its anterior surface, like the barbs of a feather upon the shaft. This tendon, however, is nothing more than the thickened posterior edge of an aponeurosis occupying the entire substance of the muscle from before backwards, and receiving the fleshy fibres upon its two lateral surfaces as far down as opposite the internal malleolus. The thick tendon resulting from the union of these aponeurotic fibres then becomes free and enters a proper sheath on the outer side of that belonging to the tendon of the flexor longus digitorum, in front of which it then passes behind the internal malleolus, where it is also inclosed in a separate sheath (*n*, *fig*. 129.). On the inner side of the internal lateral ligament of the ankle and below the lower calcaneo-scaphoid ligament it enters another sheath, and is finally inserted (*n*, *fig*. 133.) into the tubercle of the scaphoid bone, a very thick sesamoid bone existing near its insertion. In some subjects this sesamoid bone is found at the point of insertion; in others it is situated opposite the calcaneo-scaphoid ligament. Besides this the tendon of the tibialis posticus gives off a very strong expansion to the first cuneiform bone, and on the outside an oblique expansion to the second and third cuneiform bones, and even to the third or fourth metatarsal bones.

Relations. It is covered by the flexor longus digitorum, slightly by the flexor proprius pollicis, and entirely by the soleus: it covers the interosseous ligament and the adjacent parts of the tibia and fibula.

Action. The tibialis posticus extends the foot upon the leg. As it is a reflected muscle, all the fibres must be considered as acting from the point of reflection that is behind the inner ankle. It is evident, then, that this muscle extends the foot, both by its action upon the astragalo-scaphoid articulation, and also by that upon the ankle joint. It also tends to turn the sole of the foot inwards; and, consequently, it cooperates with the tibialis anticus in this respect, and antagonises the peroneus longus and brevis. It may also be understood why some persons, in whom the tendo Achillis has been cut or ruptured, are yet capable of walking, and why the foot can in all cases be extended after this accident: but under these circumstances the lever formed by the foot is changed, and the power represented by the tibialis posticus is applied between the fulcrum and the resistance; so that we have then a lever of the third, not of the second order, as when the tendo Achillis is uninjured.

The Flexor Longus Digitorum Pedis.

This is a penniform, elongated, and reflected muscle (*o*, *figs.* 130. 132.), situated along the posterior surface of the tibia and in the sole of the foot; it is the most internal muscle of the deep layer, is flattened from before backwards, and terminates below in four tendons.

Attachments. It *arises* from the tibia, and is *inserted* into the last phalanges of the last four toes. It arises from the oblique line of the tibia, below the popliteus and the soleus, and from the middle three fifths of the posterior surface of the same bone. Some fibres also proceed from the tendinous septum intervening between it and the tibialis posticus. From these different origins the fleshy fibres proceed obliquely backwards and downwards to the anterior surface and edges of a tendon, which commences near the upper end of the muscle, and gradually disengages itself from the fleshy fibres, being accompanied by them anteriorly as far as the internal malleolus. It passes behind this projection in the same sheath as the tendon of the tibialis posticus, from which it is separated by a fibrous septum; it soon leaves that tendon, passing to its outer or fibular side (*o*, *fig.* 129.), and is then reflected at an obtuse angle upon the internal malleolus. It now becomes horizontal, and is buried under the astragalus and the small anterior tubercle of the os calcis, where it is contained in a proper sheath. Having thus reached the sole of the foot (*o*, *figs.* 131, 132.) it passes obliquely outwards and forwards, crosses *under* the tendon of the flexor longus pollicis at a very acute angle, receives from it a strong tendinous communication, and at the same time becoming expanded is joined by its accessory muscle, and finally divides into four tendons for the last four toes. The tendon for the second toe proceeds directly forwards. The tendons for the other toes in succession pass more and more obliquely. Having reached the metatarso-phalangal articulations these tendons are received, together with those of the flexor brevis digitorum, into the sheaths upon the first and second phalanges; and they have precisely the same relations to the tendons of the last mentioned muscle, as the flexor profundus is observed to have with regard to the flexor sublimis digitorum in the hand; and hence the name of *perforans* given by Spigelius to the long flexor of the toes. The tendons are finally inserted into the posterior extremities of the third phalanges. The tendinous parts of this muscle are lubricated by synovial membranes where they pass through the different sheaths.

Relations. It is covered by the soleus, the posterior tibial vessels and nerves, and it covers the tibia and the tibialis posticus. In the foot, it is covered below by the flexor brevis digitorum, and the adductor pollicis.

Action. It flexes the third phalanges upon the second, the second upon the first, and the first upon the corresponding metatarsal bones. When these movements have been accomplished, it extends the foot upon the leg. From the obliquity of its reflected portion, it would turn the toes and the sole of the foot slightly inwards, if the accessory muscle did not as it were rectify its action, as well as cooperate with it. In standing it opposes flexion of the leg forwards.

The Flexor Longus Pollicis.

The *flexor longus pollicis* is the most external and the largest muscle in the deep region of the leg: it is prismatic and quadrangular, vertical and fleshy in the leg (*p*, *figs*, 129, 130.), tendinous and horizontal in the foot (*p*, *figs.* 131, 132.).

Attachments. It *arises* from the fibula, and is *inserted* into the last phalanx of the great toe. Some of the fibres arise directly from the inferior two thirds, and from the internal and external borders of the fibula; others arise from the fascia covering the tibialis posticus (its origin from the fibula, and that

from the fascia of the tibialis muscle, are separated from each other by the peroneal vessels); from a tendinous septum between it and the peroneus longus and brevis; and from a small portion of the lower part of the interosseous ligament. From these numerous points of origin, the fleshy fibres pass obliquely downwards and backwards, around a tendon which occupies the entire length of the muscle, and may be seen at the lower part of the leg, through a thin layer of muscular fibres. These fibres terminate abruptly behind the ankle joint, at the oblique groove on the astragalus, in which the tendon is lodged; it then turns into a groove on the os calcis, forming a continuation of the preceding (*fig.* 133.), and situated below that for the tendon of the flexor longus digitorum, and dips into the sole of the foot. It is retained in these two grooves, which run obliquely downwards, inwards, and forwards, by a very strong and continuous sheath (*fig.* 132.). In the sole of the foot, the tendon is deeply situated (*p*, *fig.* 131.), passes forwards, and crosses (*p*, *fig.* 132.) at an acute angle above the tendon of the flexor longus digitorum, to which it gives off a considerable fibrous prolongation. It is then received in a groove formed between the flexor brevis digitorum, and the oblique adductor of the great toe, passes below the anterior glenoid ligament of the metatarso-phalangal articulation of that toe, between the two sesamoid bones, and is received into the osteo-fibrous sheath of the first phalanx, to be inserted into the posterior extremity of the second.

Relations. It is covered by the soleus, being separated from it by a fascia, which increases in thickness as it passes downwards; it is also covered by the tendo Achillis; it covers the fibula, the tibialis posticus, the peroneal artery, and the lower part of the interosseous ligament. Externally, it is in relation with the peroneus longus and brevis; internally, with the flexor longus digitorum.

Action. It flexes the second phalanx of the great toe upon the first, and this upon the first metatarsal bone; having produced these movements, it then extends the foot upon the leg. From the obliquity of its fleshy belly it has a tendency to turn the great toe and the foot outwards. In this respect it antagonises the flexor longus digitorum and the tibialis posticus. The very strong tendinous expansion which unites it to the long flexor of the toes consolidates the two muscles; in fact, it is very uncommon to find either of them acting independently.

MUSCLES OF THE FOOT.

The extensor brevis digitorum. — Abductor pollicis pedis. — Flexor brevis pollicis pedis. — Adductor pollicis pedis. — Transversus pollicis pedis. — Abductor minimi digiti. — Flexor brevis minimi digiti. — Flexor brevis digitorum. — Flexor accessorius. — Lumbricales. — Interossei.

The muscles of the foot are divided into those of the dorsal and plantar aspects and the interossei. The muscles of the plantar aspect may be again subdivided into three regions, viz. those of the *middle plantar region*, those of the *internal plantar region*, and those of the *external plantar region*. A single muscle occupies the dorsum of the foot, viz. the extensor brevis digitorum. The muscles of the internal plantar region are four in number, viz. the abductor, the flexor brevis, and the oblique and transverse adductors of the great toe. The last two muscles may be regarded as forming part of the middle plantar region.

The muscles of the external plantar region are the abductor and the flexor brevis of the little toe.

The muscles of the middle region are the flexor brevis digitorum, the flexor accessorius, and the lumbricales.

The interosseous muscles are seven in number, and are divided into the dorsal and plantar.

Dorsal Region.

The Extensor Brevis Digitorum.

Dissection. Remove the dorsal fascia of the foot, and the tendons of the muscles of the anterior region of the leg.

The *extensor brevis digitorum* (*q*, *fig.* 128.) is a thin, flat, quadrilateral muscle, situated on the dorsum of the foot; it is divided into four portions anteriorly, and is an accessory of the extensor longus digitorum. It *arises* from the os calcis, and is *inserted* into the first four toes.

It arises, by a rounded extremity, from a small excavation on the outside of the foot, formed by the os calcis and the astragalus (*the astragalo-calcanean fossa*), and from the os calcis in front of that excavation. Its origin from these parts is both fleshy and tendinous. The muscle then passes forwards and inwards, and soon divides into four fleshy fasciculi, each representing a little penniform muscle, and terminating quickly in a small tendon, the size of which is proportioned to the strength of the fasciculus. The internal tendon is the largest, because it is intended for the great toe; it is situated below the tendon of the extensor proprius pollicis, which it crosses at a very acute angle, and is inserted into the dorsal surface of the proximal end of the last phalanx. The second, third, and fourth tendons, intended for the second, third, and fourth toes, are subjacent to the corresponding tendons of the extensor longus digitorum, which they cross at a very acute angle. Having reached the metatarso-phalangal articulations, the tendons of the short extensor are situated to the outside of those of the extensor longus, and are blended with them, so as to complete the fibrous sheath on the dorsal surface of the first phalanx, and to terminate in a similar manner.

Relations. It is covered by the dorsal fascia of the foot, by the tendons of the extensor longus digitorum and extensor proprius pollicis; it covers the second row of the tarsal bones, the metatarsus, and a small portion of the interosseous muscles, and the phalanges. The arteria dorsalis pedis runs at first along the inner border of this muscle, which overlaps the artery, where the latter perforates the first interosseous space, in order to reach the sole of the foot.

Action. It extends the first four toes; it acts upon the first phalanx only of the great toe. Its obliquity enables it to correct the contrary oblique movement communicated to the toes by the contraction of the extensor longus digitorum; so that the opposite actions of these two muscles are mutually destroyed, and the foot is extended directly. Not uncommonly, the extensor brevis presents a fifth fasciculus, which is lost upon some one of the metatarso-phalangal articulations.

Internal Plantar Region.

The muscles of the ball of the great toe may be divided, like those of the thumb, into two orders, viz. those which pass from the tarsus to the inner side of the first phalanx, and those which pass from the tarsus to the outer side of the same phalanx. Here, as with the muscles of the thumb, the tendon of the flexor longus divides the flexor brevis pollicis pedis of authors into two parts,—one internal, forming the flexor brevis of the great toe, properly so called; the other external, which is found to be connected with the oblique adductor of this toe.

Muscles inserted into the inner Side of the First Phalanx of the Great Toe.

Dissection. In order to expose the abductor brevis, it is sufficient to remove the internal plantar fascia; the flexor brevis will be found under, *i. e.* deeper than the tendon of the abductor brevis.

The muscles inserted into the inner side of the first phalanx of the great toe, are the abductor brevis and the flexor brevis. They are distinct at their origins, but are often blended at their insertions; so that Winslow united them together under the name of *le thénar du pied.*

The Abductor Pollicis Pedis.

This muscle (le court adducteur,* *Cruveilhier, r, fig.* 131.) is the most superficial in the internal plantar region; it *arises* on the inside, from the internal posterior tuberosity of the os calcis; from the internal annular ligament under which the posterior tibial vessels and nerves pass; from the upper surface of the internal plantar fascia; and from the lower surface of a tendinous expansion, which occupies the entire extent of the deep or superior surface of the muscle. From these points, the fleshy fibres proceed to the circumference of a tendon (*r, figs.* 132, 133.), which emerges from them inferiorly near the first cuneiform bone, but is often accompanied by them superiorly as far as its *insertion* into the internal sesamoid bone, opposite the first phalanx of the great toe.

Fig. 131.

Relations. It is covered below by the internal plantar fascia, and is divided from the muscles of the middle plantar region by a tendinous septum which gives attachment to some of its fleshy fibres. It is superficial to the flexor brevis pollicis, the flexor accessorius, the tendons of the flexor longus digitorum and that of the flexor longus pollicis, the tarsal insertions of the tibialis anticus and posticus, the plantar vessels and nerves, and the internal articulations of the tarsus.

Action. It is, properly speaking, a flexor of the great toe.

The Flexor Brevis Pollicis Pedis.

Adopting a similar plan in the definition of this muscle as in that of the short flexor of the thumb, I shall describe as the short flexor of the great toe, that portion (*s, fig.* 133.) only of the flexor brevis of authors, which extends from the second row of the tarsus to the internal sesamoid bone of the metatarso-phalangal articulation of the great toe, and shall refer to the oblique adductor that portion (*t*) which is attached to the external sesamoid bone. This change appears to be warranted by the rule already laid down for the distinction of muscles. Community of the fixed points of origin is not sufficient to establish the unity of two muscles, provided their moveable insertions are distinct. A cellular interval and the tendon of the flexor longus pollicis establish anteriorly the line of demarcation between the flexor brevis and the adductor obliquus pollicis.

According to this view, the flexor brevis pollicis (*s, figs.* 131, 132, 133.) *arises* from the second row of the tarsus, particularly from the cuboid and the third cuneiform bones, by some tendinous fibres which are formed by a continuation of the inferior ligaments of the tarsus, and are common to this muscle and the internal portion (*t*) of the oblique adductor of the great toe. The tendon of the tibialis posticus (*n, fig.* 133.), or rather the prolongation which this tendon gives off to the fourth metatarsal bone, also furnishes some points of origin. The fleshy fibres proceeding from these different attachments form

* See note, next page.

a bundle that gradually increases in size, becomes separated from the oblique adductor, and terminates in a tendon which is *inserted* into the external sesamoid bone and also into the glenoid ligament of the metatarso-phalangal articulation. Not unfrequently the greater number of the fleshy fibres are attached to the tendon of the abductor brevis, and thus constitute the short head of a biceps muscle.

Relations. The flexor brevis pollicis is in relation below with the internal plantar fascia, and with the tendon of the abductor brevis pollicis, being moulded upon it, and usually separated from it by a tendinous sheath, except in those cases where the two muscles are blended together. Observe that at the point where the fleshy belly of the abductor terminates, the flexor brevis is in relation above with the tendon of the peroneus longus (*e, fig.* 133.) and the first metatarsal bone.

Action. The same as that of the preceding muscle, but it is much less powerful and less extensive.

Muscles inserted into the External Side of the First Phalanx of the Great Toe.

These are the oblique and transverse adductors.*

Dissection. They are exposed by cutting across, and turning forwards the flexor brevis digitorum, the tendons of the flexor longus digitorum, and the flexor accessorius: particular care should be taken, when the dissection has extended as far as the heads of the metatarsal bones, to avoid cutting the small transverse adductor.

The Adductor Pollicis Pedis.

This (l'abducteur oblique, *Cruveilhier*, *t t'*, *fig.* 133.) is the largest of all the plantar muscles; it is prismatic and triangular, and occupies the great hollow formed by the last four metatarsal bones, and is bounded by the first metatarsal bone on the inner side. It extends from the second row of the tarsus to the external sesamoid bone of the great toe. It *arises* by two very distinct portions, the smaller (*t*, *figs.* 131, 132, 133.), common to it and to the flexor brevis, proceeds from the cuboid bone; the other (t') is much larger and arises from the sheath of the tendon of the peroneus longus (*e*), from the posterior extremities of the third, fourth, and fifth metatarsal bones, and from the transverse ligaments by which they are united. From these different origins the fleshy fibres pass more or less obliquely inwards, and are *inserted* by a tendinous bundle into the external sesamoid bone of the metatarso-phalangal articulation of the great toe, and into the posterior edge of the glenoid ligament of the same joint.

Relations. Its inferior surface is in relation with the long and short flexors of the toes, with the flexor accessorius, the lumbricales, and the plantar fascia; its *superior surface*, with the interosseous muscles and the external plantar

* [The terms adductor and abductor are applied by M. Cruveilhier to the muscles of the great toe, from their respective actions upon it, in reference to the axis of the body; the muscle attached to the inner side of that toe being called its adductor, and those to the outer side its abductors. In the translation, however, the nomenclature of Albinus has been adopted, in which the terms adductor and abductor have reference to the *axis of the limb*; first, because it is followed by the majority of authors, and, secondly, because it is in accordance with the principle observed by M. Cruveilhier himself, in describing not only all the muscles of the hand, but some even of those of the foot, viz. the interossei, which are classed by him as abductors or adductors, according as they draw the several toes from or towards an imaginary axis passing through the *second* toe. By this change much risk of perplexity will be avoided, and a uniform principle of nomenclature preserved as regards all the muscles of the hand and foot.

In the description of each muscle of the great toe, the synonymes of Cruveilhier are given between brackets; but in all instances, both here and hereafter, where these muscles have incidentally to be mentioned, the names adopted from Albinus will be strictly adhered to.

It is scarcely necessary to observe that the *abductor* of the little toe will still retain its name.]

artery; and its *inner surface* with the first metatarsal bone, the tendon of the peroneus longus, and with the flexor brevis pollicis.

Action. It is a powerful adductor and flexor of the great toe.

The Transversus Pollicis Pedis.

This small transverse bundle (l'abducteur transverse, *Cruveilhier*, *u*, *fig.* 133) forms an appendage of the preceding muscle, and is represented in the hand by the transverse fibres of the adductor pollicis; it extends from the fifth metatarsal bone to the external sesamoid bone of the metatarso-phalangal articulation of the great toe.

This muscle, which is of variable size, *arises* externally from beneath the head of the fifth metatarsal bone, by a tendinous and fleshy tongue, which is directed transversely inwards, is strengthened by other fibres arising from the anterior transverse ligament of the metatarsus, and from the interosseous aponeurosis, and is *inserted* into the outer side of the first phalanx of the great toe, where it is often blended with the attachment of the oblique adductor.

Relations. It is in relation below with the tendons of the long and short flexors of the toes and with the lumbricalis, and above with the interosseous muscles. It is lodged in the anterior part of the deep concavity of the metatarsus, and is provided with a proper sheath.

Actions. It adducts the great toe, and draws the head of the metatarsal bones towards each other.

External Plantar Region.

The Abductor Digiti Minimi.

Dissection. This is common to the abductor and the flexor brevis. The first is exposed by simply removing the external plantar fascia, and the second by removing or reflecting down the first.

The *abductor digiti minimi* (*v*, *fig.* 131.) is of the same form, the same structure, and almost the same size as the abductor pollicis, and extends from the os calcis to the first phalanx of the litttle toe. It *arises* by tendinous and fleshy fibres from the external posterior tuberosity of the os calcis, from the outer side of the internal posterior tuberosity, and from an aponeurosis occupying the upper surface of the muscle. The fleshy fibres having arisen in succession from these different points, proceed obliquely round a tendon, from which they emerge, opposite the posterior extremity of the fifth metatarsal bone. The fleshy belly of the muscle appears to end at this point, but it is continued by other fibres, arising from the upper surface of the external plantar fascia, and inserted either into the common tendon, or separately by the side of this tendon into the outer part of the first phalanx of the little toe. A small fleshy bundle is frequently detached from the body of the muscle, and implanted into the posterior extremity of the fifth metatarsal bone, together with a prolongation of the external plantar fascia, which serves as a tendon for it.

Action. It is an abductor and flexor of the little toe.

The Flexor Brevis Digiti Minimi.

This is a small fleshy fasciculus (*x*, *figs.* 131, 132, 133.), situated along the external border of the fifth metatarsal bone, and forming a continuation of the series of interosseous muscles, with which it was for a long time confounded (interosseus, *Spigelius*): it extends from the second row of the tarsus, and from the fifth metatarsal bone, to the first phalanx of the little toe. It *arises* from the ligamentous layer covering the plantar surface of the metatarsal row of the tarsal bones, and from the posterior extremity of the fifth metatarsal bone; it is *inserted* into the outer side of the first phalanx of the little toe, or, more correctly, into the posterior edge of the glenoid ligament of the metatarso-phalangal articulation of that toe. Some of the fleshy fibres will be found attached to the entire length of the external border of the fifth metatarsal bone; and these sometimes form a small and very distinct muscle, representing the opponens digiti minimi of the hand.

Fig. 132.

Relations. It is covered below by the plantar fascia, which is here very thin, and also by the tendon of the abductor digiti minimi; it is in relation above with the fifth metatarsal bone and the first plantar interosseous muscle.

Action. The same as that of the preceding muscle with regard to flexion, but its action is less powerful and less extensive.

Middle Plantar Region.

The Flexor Brevis Digitorum.

Dissection. Remove the plantar fascia, which is intimately united to this muscle posteriorly.

The flexor brevis digitorum (*y*, *fig.* 131.) is a short thick muscle, narrow behind, and divided into four tendons in front. It *arises* from the inside of the external tuberosity of the os calcis, from the upper surface of the middle plantar fascia, from a special tendinous expansion occupying the lower surface of the muscle, and appearing to be a dependence of the plantar fascia; and, lastly, from an aponeurotic septum, situated between it and the muscles of the external plantar region. It forms a fleshy belly, which is narrow and thick behind, passes directly forwards, increases in breadth, and soon divides into four, sometimes only into three fasciculi, constituting as many small and perfectly distinct penniform muscles, the long and delicate tendons of which emerge from the fleshy fibres before reaching the metatarso-phalangal articulations, become flattened, and are then situated below and in the same sheath with the tendons of the flexor longus. Opposite the first phalanx each tendon of the short flexor bifurcates, to allow the passage of the corresponding tendon of the flexor longus, is formed into a groove, becomes re-united above the latter tendon, and once more bifurcates, in order to be *inserted* along the borders of the second phalanx (hence it was named perforatus by *Spigelius*, and le perforé du pied by *Winslow*). The short flexor of the toes is therefore analogous to the superficial flexor of the fingers.

Relations. It is covered below by the plantar fascia and the skin; it is in relation above with the plantar vessels and nerves, with the tendon of the flexor longus digitorum, and with the flexor accessorius and the lumbricales, from

which it is separated by a tendinous lamina. On its outer and inner side it is completely isolated from all the adjacent muscles by prolongations of the plantar fascia.

Action. It flexes the second phalanges of the last four toes upon the first phalanges, and these upon the corresponding metatarsal bones.

The Flexor Accessorius.

This is a flat quadrilateral muscle, forming a considerable fleshy mass (massa carnea, *Jacobi Sylvii, z, fig.* 132.); it *arises* by a bifurcated extremity from the lower part of the groove of the os calcis, and a small part of the calcaneo-scaphoid ligament by fleshy fibres, and by means of a tendon from the lower surface of the same bone, this tendon sometimes extending as far as the external posterior tuberosity of the os calcis. From these points the fleshy fibres pass directly forwards, and terminate in the following manner: the lower fibres become *inserted* into the outer margin, and a small portion of the inferior surface of the tendon of the flexor longus digitorum; whilst the upper are *inserted* into several small fibrous bundles, which unite together, receive a considerable expansion from the tendon of the flexor longus pollicis, and are ultimately blended with, and increase the size of the divided tendon of the flexor longus digitorum.

Relations. This muscle is in relation *below* with the flexor longus digitorum and the plantar vessels and nerves, and *above* with the os calcis and the inferior calcaneo-cuboid ligaments.

Action. It is a muscle of re-inforcement, and assists in flexing the toes: from its obliquity it rectifies the oblique action of the flexor longus digitorum in the opposite direction.

The Lumbricales.

The lumbricales (*l l, figs.* 131, 132.), which form a second class of accessory muscles belonging to the flexor longus digitorum, exactly resemble the lumbricales of the fingers; they consist of four small fleshy tongues, decreasing in size from within outwards, the two outer of which are not unfrequently atrophied: they extend from the angles formed by the division of the tendons of the flexor longus to the inner or tibial borders of the first phalanges of the last four toes, and to the corresponding margins of the extensor tendons. They are distinguished by the numerical names of *first, second, third,* and *fourth.* The first is situated parallel with the flexor tendon of the second toe.

Relations. They are covered below by the flexor brevis digitorum; they emerge from beneath the plantar fascia, in the interval between the sheaths furnished by it to the flexor tendons, gain the inner side of the corresponding metatarso-phalangal articulation, and terminate upon the first phalanx and inner margin of the tendons of the extensor longus digitorum. They have the same *action* as the lumbricales of the hand.

Interosseous Region.

The Interossei.

The interrosseous muscles of the foot correspond exactly with those of the hand, and require the same consideration.

They *arise* from the lateral surfaces of the interrosseous spaces in which they are placed; and are *inserted* into the sides of the first phalanges and the corresponding margins of the tendons of the extensor muscles. They are seven in number, viz. four dorsal (three of which are seen at *d d d, fig.* 133.), and three plantar (*p p p*); to the latter, however, the oblique adductor of the great toe may be added, for it is nothing more than a very large plantar interosseous muscle.

As in the hand, the dorsal interrossei are abductors, their origins being situated externally to the axis of the foot; the plantar interrossei again are adductors: but the axis of the foot must be supposed to extend through the *second*, and not through the middle toe. As we observed in the hand, the dorsal interossei project into the plantar region, by the side of the plantar muscles; and so narrow are the interrosseous spaces in the foot, that these dorsal muscles are much more completely situated in the plantar, than those of the hand in the palmar region. The plantar interossei corresponding to the fourth and fifth toes, arise not only from the lower two thirds of the internal or tibial side of the corresponding metatarsal bone, but also from the lower surface of the posterior extremity of the same bone. It follows, therefore, that the interosseous muscles, viewed from below, appear one continuous muscle, in which it would be difficult to separate the muscles of each space, if the interosseous plantar fascia did not give off prolongations between them; elsewhere, a cellular line defines the limit between each plantar and dorsal muscle.

Fig. 133.

Again, as in the hand, the dorsal interossei arise from two corresponding metatarsal bones at once, but nore especially from the lateral surface of that metatarsal bone, which is lirected *from* the axis of the foot: as in the hand, also, their posterior extremities are perforated by the posterior perforating arteries, the first being erforated by the arteria dorsalis pedis. The plantar interossei arise from nly one of the metatarsal bones, and from the lateral surface that is directed *owards* the imaginary axis of the foot; moreover, they do not arise from he entire thickness of the bone, but only from its inferior two thirds, since he upper third is covered by the dorsal muscle.

The following are the general *relations* of the interossei: they are separated bove, from the tendons of the extensors, by a layer of fibrous tissue, and by he dorsal interosseous fascia; and below from the proper muscles of the oot, by the deep plantar interosseous fascia, which is much stronger than the orresponding structure in the hand, and gives off septa between the *different airs* of interosseous muscles.

PHYSIOLOGICAL ARRANGEMENT OF THE MUSCLES.

Iowever important it may be to become acquainted with the order of supermposition, or the topographical arrangement of the muscles, it is no less neessary to study the retrospective uses, in other words, the physiological rrangement of these organs.* In order to obtain as much as possible the dvantages of each of these two methods, having already described each auscle in its topographical order, I shall now give a table of the muscles, aranged according to their physiological relations. It is important to observe hat the terms, *muscles of the arm, of the thigh, &c.* have not the same accept-

* Custom, rather than conviction, has induced me to prefer the topographical to the physioigical arrangement. The only objection which can be urged against the latter is, that it does ot permit all the muscles to be dissected upon the same subject; but this objection applies nly to a few regions; and as these regions exist in pairs, the superficial muscles on one side ight surely be sacrificed. Moreover, there is no reason why the examination of the deepated muscles should not be postponed until the superficial ones have been studied. I therere direct students to dissect these parts sometimes according to their topographical, and at thers after their physiological order.

ation in the two arrangements. Thus, by the term muscles of the arm, in the topographical order, we mean the muscles which occupy the region of the arm, as the deltoid, biceps, &c.; but in the physiological arrangement, the same term is applied to the muscles which move the arm, viz. the pectoralis major, latissimus dorsi, &c.

Muscles of the Vertebro-cranial Column.

These are divided into the extensors, the flexors, and the lateral muscles or lateral flexors, which incline the vertebral column to one side or the other. There are no rotators; for rotation is performed by the extensor muscles.

Extensors. These occupy the posterior region of the vertebral column. They consist on each side of, 1. the posterior spinal, or long muscles of the back, divided into the sacro-lumbalis, longissimus dorsi, and transverso-spinalis; 2. of the transversalis colli and the trachelo-mastoideus, which may be regarded as accessory fasciculi to the longissimus dorsi; 3, of the splenius, or representative of the longissimus dorsi of the neck and head; 4. of the complexus, or *transverso-spinalis* of the head; 5. of the inter-spinales, in which the two recti postici of the head may be included; 6. of the obliquus major, or *spino-transversalis* of the atlas; 7. of the obliquus minor, or *transverso-spinalis* of the head.

Flexors. These are situated on the anterior region of the vertebro-cranial column. The most important of these muscles are carried forwards, and attached to the sternum, and to those long transverse processes called the ribs. They are on each side, 1. the rectus abdominis; 2. the sterno-cleido-mastoideus. The other muscles that cooperate in flexion occupy the deep anterior cervical region, viz. 1. the rectus capitis anticus major; 2. the rectus capitis anticus minor; 3. the longus colli.

Lateral muscles. These are, 1. the inter-transversales of the neck and loins, among which I include the rectus capitis lateralis; 2. the scaleni anticus et posticus; 3. the quadratus lumborum.

Muscles of the Ribs, or of the Thoracico-abdominal Parietes.

These are, 1. the inter-costales, externi and interni, which are both elevators and depressors; 2. the small accessory muscles, viz. the infra-costales of Verheyen and the supra-costales, or levatores costarum, the latter being always *elevators*; 3. the serrati postici superiores, which are *elevators;* 4. the serrati postici inferiores, *depressors*; 5. the triangularis sterni, or small anterior serratus, also a depressor; 6. the diaphragm, a muscular septum, the contraction of which increases the vertical diameter of the thorax, and draws the ribs inwards. The muscles of the abdominal parietes are so intimately connected in action with those of the thorax, that the description of the former naturally follows that of the latter. The abdominal muscles, then, may be regarded as muscles of expiration, and are all *depressors* of the ribs. There are, 1. the obliquus externus, which is nothing more than a large external intercostal muscle, extending between the ribs and the pelvis; 2. the obliquus internus, which may be regarded as a large internal intercostal muscle, of which the cremaster is a dependence; 3. the transversalis, which we may consider as forming with the diaphragm a single muscle, interrupted by its costal attachments.

Muscles which move the Lower Jaw.

As the bones of the upper jaw are immoveably articulated together and to the cranium, they have no proper muscles. The muscles of the face do not belong to them, but are true cutaneous muscles, attached to the different bones only for the purpose of having fixed origins. The lower jaw, on the contrary, is provided with two principal orders of muscles, *elevators* and *depressors*, to which are

added *diductors* (from *diduco*, to draw aside). The elevators and diductors preponderate; the only office of the depressors is to bring down the jaw into a position from which it may then be raised.

1. *Elevators*. These are the masseters, the temporales, and the pterygoidei interni.

2. *Diductors*, viz. the pterygoidei externi.

3. *Depressors*, consisting of the muscles of the supra- and infra-hyoid regions and more particularly of the two digastrici.

Muscles which move the Os Hyoides.

These are divided into elevators and depressors.

All the *elevators* belong to the supra-hyoid region, and are, 1. the stylo-hyoidei; 2. the mylo-hyoidei; 3. the genio-hyoidei.

The *depressors* consist of the muscles of the infra-hyoid region; viz. 1. The sterno-hyoidei; 2. the sterno-thyroidei; 3. the thyro-hyoidei; 4. the omo-hyoidei.

Muscles which move the Pelvis.

There are no muscles proper to the pelvis. The ischio-coccygeus is the only intrinsic muscle. The extrinsic muscles attached to the pelvis do not belong to its cavity, but merely take their fixed points from its parietes. It is only under particular circumstances that the pelvis changes its usual office and becomes the moveable point; for example, in the horizontal position, in the action of climbing, and in the reversed attitude of a tumbler, the pelvis is moved upon the vertebral column on the one hand, and upon the femur on the other.

Muscles which move the Shoulder.

The muscles of each shoulder are divided into elevators and depressors; both of which are also rotators. The *elevators* are, 1. the trapezius; 2. the rhomboideus; 3. the levator anguli scapulæ. The *depressors* are, 1. the pectoralis minor; 2. the subclavius; 3. the serratus magnus. The elevators and depressors of the entire shoulder must be carefully distinguished from those which raise or depress its apex.

Muscles which move the Thigh upon the Pelvis.

These muscles are divided into extensors, flexors, adductors, abductors, and rotators.

The *extensors* and *abductors* are the same, viz. the three glutæi.

The conjoined psoas magnus, iliacus, and psoas parvus constitute the only *flexor*.

Adduction is performed by four muscles, viz. the pectineus and the three adductors.

Rotation outwards is performed by six muscles, viz. the pyriformis, the two gemelli, the obturator internus, the quadratus femoris, and the obturator externus.

Rotation inwards is performed by the tensor vaginæ femoris, and especially by the anterior fibres of the glutæi, medius et minimus.

Muscles which move the Arm upon the Shoulder.

These muscles are divided into *abductors*, which are at the same time *flexors*, and into *adductors* and *rotators*. There are no proper muscles for the movement forwards or *flexion*, nor for the movement backwards or *extension*, both of which motions are effected by the adductors and abductors.

The *abductors* are, 1. the deltoideus; 2. the coraco-brachialis; 3. the supraspinatus.

The *adductors* are, 1. the pectoralis major; 2. the latissimus dorsi; 3. the teres major.

The *rotators* are, 1. the external, viz. the infra-spinatus, and the teres minor; 2. the internal, viz. the sub-scapularis.

Muscles which move the Leg upon the Thigh.

These are divided into flexors and extensors. The *flexors* are, 1. the biceps femoris; 2. the semi-tendinosus; 3. the semi-membranosus; 4. the popliteus; 5. the sartorius; 6. the gracilis.

Extension is performed by one muscle only, viz. the triceps femoralis, the long head of which is formed by the rectus femoris, and the other two heads by the triceps cruris of authors, viz. the vastus externus and vastus internus, including the crureus.

I should remark that all these muscles which arise from the pelvis perform the double function of moving the leg upon the thigh, and the thigh upon the pelvis.

Muscles which move the Fore-arm upon the Arm.

These are divided into flexors and extensors. The *flexors* are the biceps and the brachialis anticus. The *extensors* are, 1. the triceps (of which the long head resembles the rectus femoris); 2. the anconeus.

Muscles which move the Radius upon the Ulna.

These are rotators inwards, or *pronators*, viz. 1. the pronator teres, 2. the pronator quadratus; and rotators outwards, or *supinators*, viz. 1. the supinator longus, 2. the supinator brevis. The pronators occupy the anterior region, the supinators the posterior region of the fore-arm.

Muscles which move the Hand upon the Fore-arm.

These are divided into flexors and extensors. The *flexors* are, 1. the flexor carpi radialis; 2. the palmaris longus; 3. the flexor carpi ulnaris. The *extensors* are, 1. the extensores carpi radiales, longior et brevior; 2. the extensor carpi ulnaris.

Adduction and *abduction* are also performed by these muscles.

Muscles which move the Fingers.

These are divided into extensors, flexors, adductors, and abductors. The *extensors* are, 1. the extensor communis digitorum; 2. the extensor digiti minimi; 3. the abductor longus pollicis; 4. and 5. the extensor brevis and extensor longus pollicis; 6. the extensor proprius indicis.

The *flexors* are, 1. the flexor sublimis digitorum; 2. the flexor profundus digitorum, and its accessories the lumbricales; 3. the flexor longus pollicis.

The extensors and the flexors of the fingers are all situated in the fore-arm; the *adductors* and *abductors* belong to the hand: they consist of the interossei, which are seven in number, four dorsal, constituting the abductors, and three palmar, which are adductors.

Other muscles are also *superadded* to the thumb and the little finger. The muscles superadded to the thumb are, 1. those which constitute the thenar eminence (ball of the thumb), viz. the abductor brevis, the opponens, and the flexor brevis; 2. the adductor pollicis, which is nothing more than a palmar interosseous muscle. The muscles superadded to the little finger constitute the hypothenar eminence (ball of the little finger), and form, as it were, a repetition of those of the thenar eminence, viz. the abductor brevis, the flexor brevis, and opponens. But although three only are thus described, it is because

the palmar interosseous muscle of the little finger, which represents the adductor pollicis, presents no peculiarities, and is therefore classed with the other palmar interossei.

Muscles which move the Foot upon the Leg.

These are divided into flexors and extensors: the same muscles also produce, at the articulation of the two rows of the tarsal bones, movements of rotation, which correspond to *adduction* and *abduction*.

The *extensors* are, 1. the gastrocnemius and soleus, or the triceps suralis, with which we describe a small rudimentary muscle, the plantaris; 2. the tibialis posticus; 3. the peroneus longus et brevis.

There is only one *flexor*, viz. the tibialis anticus. The peroneus tertius, when it exists, is merely a dependence of the extensor longus digitorum.

There are no muscles in the leg analogous to the pronators and supinators of the forearm.

Muscles which move the Toes.

These are divided into extensors and flexors.

The *extensors* are, 1. the conjoined extensor longus digitorum and peroneus tertius; 2. the extensor proprius pollicis; 3. the extensor brevis digitorum. The *flexors* are, 1. the flexor longus digitorum and its accessories, the lumbricales; 2. the flexor brevis digitorum; the flexor longus pollicis.

Contrary to what we have seen with regard to the fingers, many of the flexors and extensors of the toes form part of the intrinsic muscles of the foot. As in the hand, the *adductors* and *abductors* of the toes occupy the thenar, hypothenar, and interosseous regions.

The interosseous muscles are adductors and abductors of the toes; they are seven in number, four dorsal, being the abductors, and three plantar, acting as adductors.

The *superadded* muscles of the great toe are, 1. the muscles of the thenar eminence, viz. the abductor brevis and the flexor brevis; 2. the adductor obliquus, and the adductor transversus. The muscles *superadded* to the little toe are the muscles of the hypothenar eminence, viz. the abductor and the flexor brevis.

Cutaneous Muscles.

These muscles, which are inserted into the skin by one of their extremities at least, are in the human subject concentrated round the openings in the face, with a single exception, viz. the palmaris brevis.

The *cutaneous muscles of the ear* belong to the orifice of the external auditory meatus, and are all rudimentary in man. They form the three auricular muscles.

The *muscles of the eyelids*, on either side of the face, are divided into constrictors and dilators. There is only one *constrictor*, the orbicularis palpebrarum, of which the corrugator supercilii may be considered an accessory.

There are two *dilators*, viz. the levator palpebræ superioris and the occipito-frontalis.

The *cutaneous muscles of the nose* consist of four or five pairs, *i. e.* on each side of the face, of the pyramidalis nasi, the levator labii superioris alæque nasi, the transversalis nasi, the depressor alæ nasi or myrtiformis, and the naso-labialis of Albinus.

The *cutaneous muscles of the lips* are, 1, a *constrictor*, viz. the orbicularis oris; 2. nine pairs of *dilators*, consisting, on each side, of the levator labii superioris alæque nasi already mentioned, the levator labii superioris, the zygomaticus major, the caninus, the buccinator, the triangularis oris, the quadratus menti, the levator labii inferioris, the platysma myoides, and often of two accessory muscles, viz. the risorius of Santorini, and the zygomaticus minor.

APONEUROLOGY.

General observations on the aponeuroses.— Structure.—Uses.

The *aponeuroses* are fibrous membranes, arranged in the form of inextensible textures, which constitute sheaths for the muscles, and, at the same time, afford them broad surfaces for attachment. The aponeuroses are generally known, at the present day, by the name of *fasciæ* (*fascia*, a band), an expression which was at first applied exclusively to the strong broad aponeurotic band, forming the termination of the tensor vaginæ femoris and part of the fascia lata of the thigh.

The aponeuroses constitute important adjuncts to the system of locomotion. They were for a long time neglected, or rather studied independently of each other, and then only partially, until Bichat gave a general view of them, in his division of the fibrous system, including the membranous forms of that tissue of which the aponeuroses form the greatest part.

As the aponeuroses have now become the object of numerous researches, and even the subject of some special treatises *, I have considered that it would be useful to offer a description of all the aponeuroses of the human body under the head of Aponeurology. This grouping together of analogous parts will have the double advantage of simplifying the description of the particular aponeuroses by making them elucidate each other, and of bringing into prominent notice a system of organs, the study of which is generally neglected in anatomical lectures.

General observations. The aponeuroses are divided by Bichat into two distinct classes, one serving for the insertion of muscles, viz. the *aponeuroses of insertion*; the other for investing or containing the muscles, called the *investing* or *confining aponeuroses.* Many aponeuroses serve both these purposes at the same time; but, in general, one or the other function predominates in each.

The *aponeuroses of insertion* † are subdivided into those formed by the expanded continuations of tendons, and those which do not originate in tendons. The aponeuroses of the gastrocnemius and soleus belong to the first class; those of the broad muscles of the abdomen are examples of the second: in the latter case the aponeuroses serve both for the insertion and investment of the muscles. Sometimes the aponeurosis occupies the middle of a muscle; as, for example, the cordiform tendon of the diaphragm, and the aponeurosis of the occipito-frontalis. The use of the aponeuroses of insertion evidently has reference to the great number of muscular fibres, all of which could not have been attached to the limited superficies of the skeleton.

The *investing aponeuroses* occasionally form a sheath for the entire limb, sometimes for only a single muscle, and at others for several muscles. The first set are called *general*, the other two *partial* aponeuroses.

The aponeuroses are found not only in the extremities where they perform such important offices, but also in the trunk. As a general rule, wherever there exists a muscle fulfilling any special purpose, and susceptible of displacement during its contraction, we find an aponeurosis, or rather an aponeurotic sheath; and the thickness of this sheath is proportioned to the length and strength of the muscle, and especially to its tendency to displacement.

Each aponeurosis presents for our consideration an *external* and an *internal surface*, a superior border or *circumference*, sometimes termed its *origin*, and an inferior border or *circumference*, sometimes called its *termination*.

1. The *external surface* of the general investing aponeuroses is in contact

* Godman, of Philadelphia, published in 1824 a special work upon the fasciæ; and Paillard a treatise upon the aponeuroses of the human body in 1827.

† See note, p. 248.

with the subcutaneous cellular tissue, from which it is separated by the superficial veins, lymphatics, and nerves. The skin is therefore moveable upon these aponeuroses, excepting in some situations, as in the palms of the hands and soles of the feet, where it is intimately united to the fasciæ by prolongations from the inner surface of the cutis. What, indeed, would be the consequences with regard to the sense of touch, or in the attitude of standing, if the skin over those regions were as moveable as it is upon the thigh? The same adhesion is also observed between the hairy scalp and the subjacent aponeurosis.

The mobility of the skin upon the aponeuroses depends upon the following contrivance. From the inner surface of the skin are given off a great number of prolongations, which, having intercepted the areolæ containing the adipose tissue, unite together and expand into a membrane, which glides over the aponeuroses and the superficial vessels and nerves: the subcutaneous membrane thus formed bears the name of the *fascia superficialis*: it is only distinctly seen in regions that are traversed by superficial vessels and nerves, as in the lower part of the abdomen, and on the extremities.

2. The *deep surface* of a general investing aponeurosis presents fibrous prolongations passing between the different layers of muscles, and even between the muscles of which these layers are composed. Moreover, this surface and its several prolongations sometimes afford attachments to the superficial muscles, and sometimes it glides over the muscles and their tendons by means of a very loose filamentous cellular tissue — an arrangement that prevails throughout the greater part of the extent of this surface. Lastly, amidst all these sheaths for the muscles, there exists a proper sheath for the principal vessels of the extremities.

These aponeurotic sheaths are not so exactly moulded upon the muscles as not to admit of the accumulation of a certain quantity of fat in their interior; nevertheless, their capacity is so far proportioned to the size of the muscles, that the latter, during their contraction, experience a degree of pressure from them which is highly favourable to their action, at the same time that it prevents all displacement.

In emaciated individuals these sheaths are no longer filled by their respective muscles; and, without doubt, the want of a due compression upon the muscles has some influence in producing the weakness experienced by convalescents, or by those wasted by some chronic disease.

3. The *borders* or *circumferences* of aponeuroses, incorrectly named their origin and termination, are either continuous with the aponeuroses of the adjacent regions, or are attached to the processes on the articular extremities of the bones, or result, in part, from the expansion of tendons.

The aponeuroses are perforated by vessels and nerves, which, in such cases, are guided and protected by arches, rings, or canals of fibrous tissue: of this nature are the sheaths of the femoral artery and vein, and of the brachial artery and veins, the femoral arch, the canal and arch of the adductor muscles of the thigh, the arch of the obturator foramen, and the aortic arch of the diaphragm; these canals and arches tend to prevent any injury to the vessels and nerves by which they are traversed during the contraction of the muscles. We must not suppose, however, that the vessels are exempt from all pressure; for experience has proved that arteries are particularly liable to become affected with aneurism in the neighbourhood of such arches; as, for example, the popliteal and femoral arteries and the aorta. The muscular fibres, in fact, are not attached to these arches in such a manner as to dilate them in all directions during their contraction, but rather in such a way as to elongate them in one direction and contract them in another.

All the aponeuroses, whether of insertion or of investment, have their tensor muscle. With regard to the aponeuroses of insertion, this requires no proof; for the action of the muscle or muscles to which they afford attachment must necessarily render them tense. It is no less true, however, of the investing aponeuroses, some of which have even a separate muscle for this purpose. Thus the occipital and frontal muscles are tensors of the occipito-

frontal aponeurosis. The fascia lata is rendered tense by the tensor vaginæ femoris, the palmar fascia by the palmaris longus, &c.

The aponeuroses of both kinds are inextensible, resisting, and insensible membranes, their thickness and strength being exactly proportioned to the resisting power and strength of the muscles which are invested by them, or to which they afford the means of insertion. Thus, the fascia of the thigh is very much stronger than that of the arm: the thickness of the aponeuroses increases from the upper to the lower part of the limbs; and again the powerful vastus externus is provided with a much stronger sheath than the muscles of the posterior, or of the internal region of the thigh. We may then consider it as a general law without exception, that the aponeurotic system invariably presents a corresponding degree of developement to that of the muscular system. We should therefore study the aponeuroses, as well as the muscles, upon robust subjects; their pearly aspect is destroyed in individuals wasted by chronic diseases. The aponeurotic and muscular systems are both most fully developed in carnivora; in which class of animals the pearly appearance is peculiarly well marked, and the cellular tissue is often replaced by a fibrous texture, a transformation which proves the analogy of the cellular and fibrous tissues in organisation, vitality, and function.*

The thinner fasciæ are composed of a single layer of parallel fibres, which have between them intervals of different sizes: stronger aponeuroses are composed of several planes, the fibres of which intersect each other at various angles. The vessels and nerves of the aponeuroses are little known; but I believe that I have traced nerves into them. I have certainly done so with regard to the dura mater.*

I shall include among the aponeuroses the *fibrous sheaths of tendons* *, which are sometimes presented under the form of imperfect rings, or canals of different lengths, which retain the tendons in contact with the bones. They serve to confine the tendons, to keep them applied against the bones, and to favour their reflection.

The *periosteum* * must also be annexed to the aponeurotic system,; it is a true aponeurosis, covering every part of the bones, and constituting a fibrous sheath for them. We may consider the periosteum as the central point of the aponeurotic system, proceeding from which, we find either tendons expanding upon the surface or in the substance of muscles, and constituting the aponeuroses of insertion; or else those fibrous cones or pyramids, from the interior of which the fleshy fibres take their origin. From the periosteum, or rather from the ridges or clefts by which the surfaces of bones are marked, both the partial and general investing aponeuroses arise. In this way the muscles of the extremities are situated between two fibrous layers; the deep layer consisting of the periosteum, the superficial layer of the general investing fascia: numerous septa pass from one to the other, and divide the limb into a number of compartments, intended to isolate, confine, and protect the different muscles.

Use of the aponeuroses. Forming as they do an important division of the fibrous textures, they partake of the physical, chemical, anatomical, physiological, and pathological properties of that tissue.

1. From their great strength they are enabled to resist the powerful traction and distension exercised upon them by the muscular fibres. Their division or destruction is accompanied by displacement of the parts which they are intended to bind down. Between the different layers of the regions of the body, they establish very precise limits, a knowledge of which is of the greatest importance, in enabling us accurately to account for many morbid phenomena, and in guiding us in the performance of surgical operations.

2. They are inextensible; hence the resistance which they oppose to the developement of subjacent parts, and the tension produced by inflammation of

* See note, p. 389.

organs situated beneath them. They yield to gradual distension, but then become thinner and weaker, and can only imperfectly fulfil their proper offices.

3. They are totally inelastic, and therefore when distended beyond a certain point never return to their original dimensions. Of this we have an example in the condition of the abdominal parietes after utero-gestation, or ascites.

4. The low degree of vitality they possess, explains why they are so slightly involved in inflammation or other morbid conditions of the adjacent structures, and also the fact of their establishing limits beyond which these diseases seldom pass. They are insensible to all ordinary stimuli, but become painful when they are violently overstretched. The plantar fascia, under such circumstances, becomes extremely sensitive.

Having made these general remarks, we shall now describe, in succession, the principal aponeuroses of the human body.*

* *Note on Aponeurology.* [The analogy existing between the cellular and aponeurotic investments of various organs, renders it advantageous to consider in this place the general anatomy of the *cellular* and *fibrous* tissues.

The ultimate elements of both these kinds of tissue are precisely similar, though somewhat differently arranged in each; they consist of delicate transparent filaments, varying in diameter from $\frac{1}{20000}$th to $\frac{1}{13000}$th of an inch, and having a peculiar sinuous or undulating direction; they are insoluble in cold water, but by long continued boiling are almost entirely converted into gelatine.

In *cellular tissue* these undulating filaments are arranged side by side, either into larger compound and flexuous fasciculi, or into thin transparent laminæ, which cross and intersect one another in all directions, so as to leave interstitial cavities or areolæ, freely communicating with each other, and moistened by an albuminous fluid. The tissue thus formed, more properly called areolar, or filamentous, is of a greyish aspect, and highly elastic; the latter property depending not on any innate elasticity in the ultimate filaments, but on the sinuous disposition of those filaments, and of the fasciculi into which they are collected. But few vessels, and still fewer nerves, are believed to terminate in this tissue. It is continuous over the whole body; hence the great extent to which it may be affected with diffuse inflammation: it also invests and isolates parts, forms the matrix of nearly all organs, and the basis of many membranes; and is called, according to its position, investing, intermediate, penetrating, parenchymatous, or submembranous. The characters above described are most strongly marked in the loose cellular tissue, examples of which are met with in the axilla, under the subscapular muscle, between the free surfaces of muscles and their sheaths, behind the kidneys, &c. In other situations it is more condensed, as in the subserous, submucous, and subcutaneous cellular tissues; in the latter of these, or the superficial fascia, and also in the cutis itself, it approaches to the fibrous tissue both in density and in the mode of arrangement of its elementary filaments, and is therefore termed *fibro-cellular tissue.* From this variety the transition is natural to the fibrous tissues, properly so called.

In *fibrous tissue* the undulating primitive filaments are also arranged side by side into fasciculi, which differ from those of cellular tissue in being much larger, more dense, and more opaque, and in being straight instead of flexuous. They are white, shining, strong, and almost inelastic, qualities depending on the compact parallel disposition of the component filaments, and the slight amount of elasticity in particular on the absence of sinuosity in the compound fasciculi. According to the manner in which these fasciculi or fibres (as they are termed) are arranged and combined, we have either the membranous or the fascicular form of fibrous tissues.

In the *membranous* form there are some which closely resemble the fibro-cellular membranes already alluded to, and consist of the shining fibres crossing each other in all directions (without anastomosis), and intermixed with more or less condensed cellular tissue; for example, the thinner investing aponeuroses, the capsular ligaments, the pericardium, tunica albuginea, periosteum, and dura mater. In others, again, the fibres are more parallel, though still intersected, and combined with cellular tissue, as in the fascia lata of the thigh, and in other strong investing aponeuroses. In the aponeuroses of insertion of the broad muscles, and in the expanded terminations of tendons, there is scarcely any cellular tissue, whilst the parallel arrangement is yet more perfect; and, finally, the latter attains its utmost perfection in the round ligaments, and in tendons, which constitute the *fascicular* form of fibrous tissue, and the type of the tissue itself.

These textures contain but few nerves and vessels. The distribution of a branch of the fourth cranial nerve to the dura mater, alluded to in the text, has been confirmed by other anatomists. Bloodvessels abound in the periosteum, but they merely divide in that membrane, so as to enter the bone at a great number of points.

The *sheaths of tendons* (classed amongst the fibrous tissues by M. Cruveilhier) display a tendency to become fibro-cartilaginous, especially at and near their attachments to the bones. They have hitherto been described (ex. gr. pp. 325. 335.) as if lined by vaginal synovial membranes (note, p. 226.). According to Dr. Henlé, however, their interior is not covered by an epithelium. The bursæ, or so called bursal synovial membranes, formed between the tendons of muscles (p. 346.), between tendons and bones (pp. 346, 347. 349.), and between the skin and projecting parts of bones, as over the patella, the olecranon, &c. according to the same authority, are also destitute of epithelium. It would appear, therefore, that although these cavities resemble in function the true synovial membranes, they differ anatomically from them, and consist merely of shut sacs formed in the general cellular texture of the body. Such bursæ, however, as communicate with the synovial capsules of joints (p. 279. 317.), are probably lined by an epithelium.]

PARTICULAR APONEUROSES.

Superficial fascia.—Aponeuroses of the cranium—of the face—of the neck—of the thorax—of the abdomen—of the pelvis—of the thigh, leg, and foot—of the shoulder, arm, forearm, and hand.

The Superficial Aponeurosis, or Superficial Fascia.

From every point of the deep surface of the skin, fibrous cellular lamellæ arise, which intersect each other in various directions, so as to form meshes or areolæ, containing adipose tissue in ordinary circumstances, and a serous fluid in œdema.* The cutaneous muscle (*panniculus carnosus*) of the lower animals, is developed in these laminæ; and amongst them are situated the subcutaneous vessels and nerves, and the lymphatic glands. The name of *fascia superficialis* has been of late applied to this assemblage of lamellæ.

It was pointed out in a particular manner by Glisson, who described it under the name of the general investment of the muscles, proceeding from the spine, and covering the whole body; Camper, Cowper, Scarpa, Hesselbach, Lawrence, J. Cloquet, &c. have described it upon the abdomen, in its relation with herniæ; Godman has spoken of its existence over the entire surface of the body; M. Paillard, in his inaugural dissertation, traced it with still greater exactness; MM. Velpeau and Blandin, in their *Traités d'Anatomie Chirurgicale*, consider it as existing in almost all regions of the body.

But if the word aponeurosis be employed in its ordinary acceptation, it will be found that a fascia superficialis, consisting of a fibrous texture capable of anatomical demonstration, exists only in two kinds of situations, viz. in those where the skin is extremely moveable, and in those where there is a layer of subcutaneous vessels and nerves: in both these cases the fibrous prolongations from the skin are expanded into a thin lamina, constituting a superficial covering for these vessels and nerves, and separated from the fibrous investment of the muscles by a layer of cellular and adipose tissue of variable thickness. In all other parts, the fibro-cellular prolongations of the skin become continuous either with the investing aponeuroses, or with the proper fibro-cellular sheaths of the muscles, or are lost in the subcutaneous cellular tisue. So true is this, that this thin areolar layer, which can with difficulty be separated from the skin in emaciated persons, disappears altogether in those whose cellular tissue is distended by fat or serous effusion.

Having made these remarks, I shall describe the superficial fascia in those regions only where it can be easily demonstrated, viz. in the lower part of the abdomen, and in the extremities.

The Superficial Fascia of the Abdomen.

This aponeurosis, from its constituting the first subcutaneous covering of herniæ, has particularly engaged the attention of authors who have specially treated of the pathological anatomy of those diseases.

It becomes evident in the neighbourhood of the umbilical region, but is much more distinct at the fold of the groin, where it divides into two layers, one of which is attached to the femoral arch, and the other is prolonged upon the lower extremity. It is bounded on the inside by the median line, and on the outside by another line, extending perpendicularly upwards from the anterior superior spinous process of the ilium. It is prolonged over the inguinal ring, and over the spermatic cord in the male subject.

It has been said that in the fœtus, before the descent of the testicle, the superficial fascia dips into the inguinal canal, and forms an infundibuliform pro-

* [Adipose tissue is never deposited in the subcutaneous tissue of the eyelids, nor in the male organ of generation. These parts, however, may become much distended from serous infiltration.]

longation, reaching up to the lower part of that gland; and the dartos has been supposed to result from the expansion of this fascia—a description which can be regarded only as an ingenious speculation, which has not been confirmed by actual dissection.

Lastly, the external surface of the superficial fascia of the abdomen is in relation with the skin, separated from it, however, by a layer of adipose tissue of variable thickness, in which the subcutaneous vessels and nerves are situated. Its deep surface corresponds with the aponeurosis of the external oblique muscle, and with a portion of its fleshy fibres: from these parts it is separated by a layer of serous cellular tissue, which enables it to be moved easily upon this muscle and the subcutaneous vessels and nerves.

The Superficial Fascia of the Upper and Lower Extremities.

These are thin fibrous sheaths, separated from the skin by a greater or less quantity of adipose tissue, and from the investing aponeurosis of the muscles by the subcutaneous vessels and nerves. It does not exist around the joints, nor in the palms of the hands and soles of the feet, for in these places the skin adheres to the subjacent aponeuroses.

The Aponeuroses of the Cranium.

The Occipito-frontal or Epi-cranial Aponeurosis.

This is a sort of tendinous or cutaneous cap (*galea capitis*), stretched between the two frontal and two occipital muscles. Its *superficial surface* is intimately adherent to the skin, by means of very short and strong fibrous prolongations, between which the fatty matter is deposited: the frontal, occipital, temporal, and auricular vessels and nerves, traverse this adipose tissue. Its *deep surface* glides upon the periosteum of the skull (*pericranium*), by the intervention of a very delicate cellular tissue, in which fat is never found. Its anterior margin receives the fibres of the frontal muscles, forming a triangular point between them; its posterior margin receives the fibres of the occipital muscles, and also occupies the interval between them. These two muscles act as tensors of the aponeurosis. Its outer margin gives attachment to the superior and anterior auricular muscles. It is composed behind of shining fibres, which seem to form a tendon of insertion to the occipitalis muscle, but it soon loses its pearly appearance, and becomes more adherent to the skin: it is thick and strong at the upper part of the head, but thin and almost cellular at the sides: it may be regarded as a dependence of the superficial fascia. It gives rise to the tension which is so common and so dangerous in inflammations of this region. Its adhesion to the skin explains the shallow character of ulcers, and the flatness of the small abscesses occurring in these parts.

The Temporal Aponeurosis.

Besides the tendinous origin of the temporal muscle, which has been already described, there is also a very strong investing aponeurosis, arising from the upper border of the zygomatic arch, and inserted into the curved line bounding the temporal fossa above. This aponeurosis completes the sort of case in which the muscle is contained; and the space between it and the temporal fossa corresponds with the thickness of the muscle.

It differs from the epicranial aponeurosis, which is more superficial and covers it superiorly, in not adhering to the skin, which glides very easily upon it. Its deep surface adheres to the upper part of the muscle, and furnishes it with numerous points of attachment; below it becomes free, and is separated from the fleshy fibres by a considerable quantity of fat; hence the depression formed in this situation in emaciated persons.

It increases in thickness from above downwards; it divides below into two layers—one superficial and thinner, inserted into the outer edge of the upper

border of the zygoma; the other deep and thicker, attached to the inner surface of that process. In tolerably stout persons a considerable quantity of fat is situated between these two layers, and a remarkable branch of the temporal artery also occupies the same situation. This fat must not be confounded with the larger mass which lies beneath the aponeuroses. The resistance of this fascia explains the reason why abscesses in the temporal fossa never point outwards, but rather tend downwards into the zygomatic fossa.

The Aponeuroses of the Face.

The Parotid Aponeurosis.

This is a sheath of great thickness, especially that part which covers the outer surface of the gland; it is continuous below with the cervical fascia. It belongs especially to the gland, for which it forms a framework by means of fibrous prolongations from its deep surface. The density of this sheath explains both the pain caused by inflammation of the gland, and the difficulty with which pus makes its way from within it to the surface.

The Masseteric Aponeurosis.

This is a thin tendinous layer covering the masseter muscle, and continuous below with the cervical fascia; it appears to divide behind into two layers, one of which constitutes the parotid fascia, and the other penetrates between that gland and the masseter; above and anteriorly it becomes merged into the cellular tissue. Purulent matter situated beneath this fascia tends downwards into the neck, but when situated superficially to it points towards the skin.

The Buccinator Aponeurosis.

The buccinator is covered by a closely adherent fibrous layer, which is regarded as the expansion of the fibrous sheath of the Stenonian duct; it is thickest behind, where it is termed the buccinato-pharyngeal aponeurosis, because it gives attachment behind to the superior constrictor of the pharynx, and to the buccinator in front. This aponeurosis prevents superficial abscesses from opening into the mouth, and is also opposed to the extension outwards of diseases attacking the mucous membrane.

The Cervical Aponeurosis, or Cervical Fascia.

In the cervical region we find, 1. the cervical fascia; 2. the prevertebral aponeurosis.

The Cervical Fascia.

The cervical aponeurosis covers the whole anterior region of the neck; it extends from the base of the lower jaw to the sternum and clavicles, and is insensibly lost on either side in the subcutaneous cellular tissue. It is thick in the median line, and forms a sort of *cervical linea alba.* From this linea alba two layers proceed in the supra-hyoid region, and four in the infra-hyoid region, which are arranged in the following manner:—

1. The *superficial layer*, or the *superficial cervical fascia*, covers the whole anterior and lateral regions of the neck, is prolonged downwards in front of the clavicle, to become continuous with the proper aponeurosis of the pectoralis major, is attached above to the masseteric and parotid fasciæ, and, internally to the masseter muscle, is fixed to the base of the lower jaw.

It fills up the interval between the two platysmata, and is prolonged behind these muscles to form the anterior layer of the sheath of the sterno-mastoid. The external jugular vein is superficial to this layer in the sub-hyoid, and lies beneath it in the supra-hyoid region.

2. The *deep layer* passes beneath the sterno-mastoid, on the outer border of which it unites with the preceding layer, and completes the sheath for that muscle. It covers the internal jugular vein, the common carotid artery, the pneumogastric nerve, the great sympathetic, and its cervical ganglia. Its upper margin is attached to the base of the lower jaw ; its lower margin to the posterior surface of the clavicle, and to the posterior edge of the fourchette of the sternum. It is necessary to examine this deep layer, both in the supra- and sub-hyoid region.

In the supra-hyoid region its middle portion is very strong, and occupies the triangular space between the anterior bellies of the digastric muscles: it is fixed by its lower margin to the os hyoides, and on each side to the tendon of the digastricus. The lateral portions of this aponeurosis pass beneath the submaxillary glands, and are attached to the rami of the lower jaw. Externally to these glands they join the parotid aponeuroses, and form a tolerably thick septum between the submaxillary and parotid glands of either side.

In the *sub-hyoid region* this deep layer is divided into three very distinct parts, a middle and two lateral. The middle is the stronger ; it occupies the triangular space between the two omo-hyoid muscles, and becomes continuous with their median tendons: the muscles may therefore be regarded as the tensors of this fascia. It binds down the muscles of the infra-hyoid region: its arrangement explains why abscesses situated in front of it discharge their contents through the skin, and not into the thorax, as those do that are subjacent to it. The lateral parts of the aponeurosis constitute the *supra-clavicular fascia*, a very strong layer, in which the superficial layer already described, and the two which yet remain to be noticed, all terminate. It occupies the whole triangular space between the trapezius and the sterno-mastoid, is continuous with the fibro-cellular sheath of the former muscle, and adheres below to the clavicle. The latter circumstance is of great importance in relation to surgical anatomy.

The superficial and deep layers which we have now described, are common to both the supra- and sub-hyoid regions. In the sub-hyoid region there are *two other aponeurotic layers* ; one, very thin, separating the superficial from the deep muscles, *i. e.* the omo- and sterno-hyoidei from the sterno-thyroidei and thyro-hyoidei ; the other, thicker, passing between the sterno-thyroidei and the trachea. The latter is the fourth layer which Godman incorrectly describes as continuous with the pericardium.

The Prevertebral Aponeurosis.

This aponeurosis covers the muscles of the prevertebral region, viz. the longi colli and the great and small anterior recti : it is prolonged on each side upon the scaleni, the levator anguli scapulæ, and the brachial plexus ; and is attached to the upper border of the scapula, and to the outer half of the posterior border of the clavicle. It completely separates the axilla from the neck, and is perforated by several vessels. It prevents large abscesses of the neck from opening into the axilla ; and in caries of the cervical vertebræ it retains the pus poured out against it, so as to form abscesses by accumulation.

The Thoracic Aponeuroses.

The Intercostal Aponeurosis.

Independently of the semi-tendinous structure of the intercostal muscles, we find several fibrous layers in each intercostal space ; one layer, in front, continuous with the external intercostal muscle ; another, behind, continuous with the internal intercostal muscles ; and, situated within these muscles, a third layer, which lines them and separates them from the pleura. The existence of this subserous aponeurosis accounts for the rare occurrence of the bursting

of an external abscess of the chest, into the cavity of the pleura; and on the other hand, of the escape of collections in the pleura by external openings.

The Aponeurosis of the Serrati Postici.

In the dorsal region of the trunk, we find a very thin fibrous layer (sometimes called the vertebral aponeurosis), extending between the two serrati postici. It is of a quadrilateral form; its inner margin is attached to the summits of the dorsal spinous processes; its outer margin to the angles of the ribs; and its lower margin to the upper border of the serratus posticus inferior; it seldom terminates at the lower border of the serratus posticus superior, but generally passes beneath it, and becomes the investing aponeurosis of the splenius. The use of this aponeurosis is evidently to confine the posterior spinal or long muscles of the back.

The Abdominal Aponeuroses.

The parietes of the abdomen are partly muscular and partly aponeurotic: the muscular portions are situated at the sides of the abdomen. The aponeurotic portions occupy the anterior and posterior regions, and form the *anterior* and *posterior abdominal aponeuroses*. The extensibility, elasticity, and above all the contractility of the abdominal parietes, depend on the three intersecting muscular layers; whilst to the aponeuroses must be attributed their capability of resistance and want of extensibility.

The Anterior Abdominal Aponeurosis.

The anterior abdominal aponeurosis forms the greater part of the anterior wall of the abdomen. It consists, 1. of a fibrous column, which is continuous with the osseous column of the sternum, and 2. of two perfectly corresponding halves, one right, the other left. These two halves are united in the *linea alba*, which may be regarded as their common origin.

The Linea Alba.

The linea alba (*i, figs.* 109, 110.) is a tendinous raphé, extending from the ensiform cartilage to the symphysis pubis; it constitutes the anterior median line of the abdomen. In a theoretical point of view it may be regarded as a continuation of the sternum, which, in some animals, is prolonged as far as the pubes.*

Anatomists are not agreed as to the acceptation of the term linea alba. According to some it is a mathematical line produced by the intersection of the aponeuroses of one side with those of the other: according to others, and this meaning appears to me preferable, it consists of the tendinous band comprised between the inner borders of the recti.

Thus defined, the breadth of the linea alba corresponds to the interval between these muscles, and as they are directed somewhat obliquely upwards and outwards, it follows that the upper or supra-umbilical portion of the linea alba is broader than that portion which is below the umbilicus. This remarkable arrangement, by which the strength of the lower part of the abdomen is secured, affords an explanation of the uniform occurrence of herniæ through the linea alba above, not below, the umbilicus. It should also be observed that, during exertion, the viscera are chiefly forced against the lower part of the abdominal parietes, and also that the gravid uterus rests upon it.

The sub-umbilical portion of the linea alba forms a mere line, while the

* The analogy has even been carried so far, that the tendinous intersections of the recti have been compared to the ribs, for they seem to come off from the linea alba like abdominal ribs.

supra-umbilical is about a quarter of an inch in breadth. Its transverse dimensions are much increased in persons whose abdomen has been greatly distended. Thus, during and after pregnancy and certain dropsies, it in some cases acquires a considerable breadth, and does not return to its original size, even after the distension has ceased to exist. In a female who died a short time after delivery, I found the linea alba three inches across at the umbilicus, and fifteen lines in the narrowest part. In cases of this kind, the linea alba forms a sort of long pouch, which receives the intestines, and becomes very prominent during the contraction of the recti.

The linea alba presents several elliptical openings for the passage of nerves and vessels. In these foramina round masses of fat are developed, which dilate them, and draw down the peritoneum into them, or are absorbed in consequence of emaciation, and thus open an easy way for the production of hernia of the linea alba. Of all these orifices, the most remarkable is the *umbilical ring*, which gives passage to the umbilical vessels in the fœtus, but becomes cicatrised after birth, at least in the majority of subjects.*

The situation of the umbilicus varies at different ages. The middle point of the length of the body is situated above the umbilicus before the sixth month of fœtal existence, and corresponds with it after that period. In the adult it is situated below the umbilicus. Its situation with regard to the abdomen varies in different individuals. Thus, the umbilical cicatrix, which is generally a little below the middle of the abdomen, is sometimes exactly in the middle. I have even seen it at the point of junction of the lower with the upper two-thirds.

This cicatrix, moreover, is much stronger than the neighbouring parts. Thus, an umbilical hernia, which in a new-born infant always occupies the navel itself, in an adult is almost invariably situated a little above the umbilicus. Still it occasionally yields, either in cases of dropsy, or of hernia; and I have records of several instances of hernia in the adult, that have occurred through the umbilical ring.

The linea alba is in relation, *in front*, with the skin, which adheres more closely to it than to the neighbouring parts, especially opposite the umbilicus. In the male it is separated from the skin below by the suspensory ligament of the penis, which sometimes extends as far as the middle of the space between the pubes and the umbilicus: *behind*, it is in relation with the peritoneum, separated from it, however, by the remains of the urachus, and by the bladder itself, when that viscus is distended. It is, then, through the linea alba that the bladder is punctured in cases of retention of urine, and that the incision is made in the high operation of lithotomy. The peritoneum does not adhere more closely to the umbilicus than to the other parts of the abdomen, and therefore umbilical herniæ, like all others, are invariably provided with a proper sac.

The *upper extremity* of the linea alba is attached to the ensiform appendix, a flexible, elastic, cartilaginous body, constituting, as it were, a transitional structure between the sternum and the part we are now describing.

The *lower extremity* corresponds to the symphysis pubis.

If we examine the structure of the linea alba, we shall see that it is formed by the intersection of the layers of the anterior abdominal aponeuroses. One remarkable circumstance is, that the intersecting fibres do not stop at the median line, but pass from one side to the other; so that the tendinous fibres of the external oblique of the right side, become the tendinous fibres of the internal oblique of the left; and again, that the intersection occurs not only from side to side, but also from before backwards. Below the umbilicus the point of intersection is elevated by some longitudinal fibres, constituting a

* Some cases are on record of the persistence of the umbilical vein, and consequently of the umbilical ring. I have narrated a case where a subcutaneous abdominal vein, prodigiously developed, became continuous with the vena cava, which was also very large. (*Anat. Path.* l. xvi. pl. 6.)

small and very distinct cord, which appears to form a septum between the recti muscles; it increases in thickness as it proceeds downwards from the umbilicus to the symphysis, and may be easily felt under the skin in emaciated individuals. We may add, that the fibres of the linea alba have no resemblance to the yellow elastic tissue; they are neither extensible nor elastic, at least in the human subject. Its uses entirely refer to its capability of offering resistance.

The pyramidales are its tensor muscles.

The Four Layers of the Anterior Abdominal Aponeurosis.

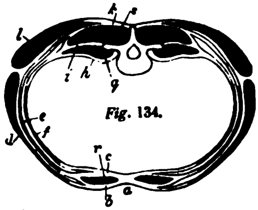


Fig. 134.

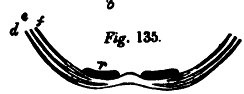


Fig. 135.

From each side of the linea alba (*a*, *fig.* 134., a diagram representing a horizontal section of the abdominal parietes) two fibrous layers proceed outwards,—one anteriorly, the other posteriorly, to the rectus muscle (*r*).

The anterior layer (*b*) having arrived near the outer border of the muscle, subdivides into two other layers,—one *superficial*, constituting the aponeurosis of the external oblique (*d*); the other *deep*, forming the anterior layer of the aponeurosis of the internal oblique (*e*). The posterior layer (*c*) is also simple as far as the outer border of the rectus, and then separates likewise into two layers,—one *anterior*, which becomes united with the aponeurosis of the internal oblique (*e*), and is regarded as the posterior layer of that aponeurosis; the other *posterior*, which continues its course outwards from the rectus, and forms the aponeurosis of the transversalis muscle (*f*). We shall describe these different parts in succession.

The aponeurosis of the external oblique. This is the most superficial layer, and is of a quadrilateral figure (*a*, *fig.* 109.); it is broad below, where it corresponds to the interval between the anterior superior spinous process of the ilium and the linea alba, becomes narrower immediately above, and again expands at the upper part, but to a less extent than below.

It is covered by the skin and the superficial fascia, and it covers the aponeurosis and the anterior portion of the fleshy fibres of the internal oblique. It adheres intimately to the aponeurosis of the internal oblique, as far as the vicinity of the outer border of the rectus, excepting below, where the two fasciæ are perfectly distinct, and can be easily separated throughout their entire extent.

Its *external margin*, slightly concave and denticulated, presents irregular prolongations, with which the fleshy fibres become continuous. A line extending from the anterior superior spinous process of the ilium to the extremity of the cartilage of the eighth rib, will indicate with tolerable accuracy the direction of this margin, which appears to be divided into two layers,—one superficial, very thin, and continuous with the proper cellulo-fibrous sheath of the muscle; the other deep, and giving origin to fleshy fibres.

Its *upper margin* is narrow, and cannot be exactly defined; it often gives attachment to some fibres of the pectoralis major.

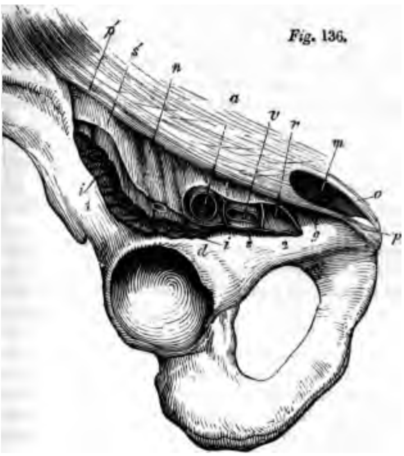
Its *lower margin* consists of two very distinct portions,—one extending from the anterior superior spinous process of the ilium to the spine of the os pubis, is called the *femoral arch* (*p p'*, *figs.* 136, 137.); the other, stretching between the spine and the symphysis pubis, offers for consideration the pillars and the cutaneous orifice of the *inguinal canal* (*m*, *figs.* 109. 136, 137.).

The aponeurosis of the external oblique is composed of tendinous fasciculi, directed obliquely downwards and inwards, like the fleshy fibres with which they are continuous. It is also perforated, especially in the neighbourhood of

, alba, by a considerable number of bloodvessels and nerves. Not ntly the component fasciculi have between them, especially near the ırch, linear or triangular spaces of variable size, through which the the internal oblique are visible. The component fasciculi are also ed at right angles, and as it were bound down, by other tendinous hich are more or less developed in different individuals, and are most ituated in the neighbourhood of the femoral arch.

g made these preliminary observations we shall now describe in detail, wer margin of the aponeurosis of the external oblique or the *femoral* d 2. the *inguinal ring* and *canal*.

moral, or crural, arch. When the aponeurosis of the external oblique ed opposite a line extending from the anterior superior spinous process ım to the spine of the pubes, it suddenly terminates, becomes thickened, flected (*a a'*, *fig.* 137.) from before backwards upon itself. The reflected border (*p p'*, *figs.* 136, 137.) has been variously denominated the *femoral* or *crural arch*, the *reflected margin of the tendon of the external oblique*, *Poupart's ligament*, and the *ligament of Fallopius*. This arch, which is stretched like a cord, corresponds to the fold of the groin, and defines the limits of the abdomen and the lower extremity: it forms the anterior border of a considerable triangular space, which is completed by the ilium (1, *fig.* 136.) on the outside, and by the os pubis (2) be-



ıis space establishes a communication between the lower extremity bdomen, and is occupied (proceeding from without inwards) by the l iliacus muscle (*i* to *i*), the crural nerve (*n*), the femoral artery (*a*) (*v*), and the pectineus muscle.*

ıral arch is *directed* somewhat obliquely downwards and inwards; and r third is more oblique than the inner two thirds, it describes ex- slight curve, having its concavity directed upwards. Its *lower* or order is continuous with the fascia of the thigh. This adhesion occa- tension of the arch, as may be shown by cutting the femoral fascia at of its junction with the arch: hence the precept of Scarpa, who re- ed incisions to be made in this situation, in order to relieve the con- n femoral herniæ.

e margin of the reflected portion of the aponeurosis, of which the rch consists, is continued backwards into the iliac fascia (*s'*) ex- and internally, into the fascia transversalis (*t*).

ılly near the psoas and iliacus, (beyond *a'*, *fig.* 137.) the posterior or ortion of the arch is closely blended with its anterior or direct por-

* This is not represented in the woodcut.

tion, as well as with the iliac fascia and the fascia of the thigh, so that in this situation there is a thickening rather than an actual reflection of the aponeurosis. Internally to the psoas and iliacus, however (at *a*), the direct and reflected portions are perfectly distinct, and form a groove with its concavity upwards, which we shall find to assist in the formation of the inguinal canal. These two separate portions of the inner part of the femoral arch require a special description.

The *direct portion* (part of which is shown turned downwards at *d*, *fig.* 137.), passes on to be attached to the spine of the pubes (*p*, *figs.* 136, 137.), becoming more and more prominent, so that it can be easily felt under the skin, especially when the thigh is extended upon the pelvis. The *reflected portion*, externally, is narrow, and as it were folded; but internally it becomes expanded, from its fibres slightly changing their direction, and diverging, so as to be inserted into the spine of the pubes behind the direct portion, and also into the pecten or crest of the pubes.

This reflected and expanded portion, described even in the oldest anatomical works, has become celebrated in recent times under the improper name of *Gimbernat's ligament* (*g*, *fig.* 136.), from a Spanish surgeon, who pointed out its importance as the seat of stricture in femoral hernia. It is triangular in shape; its anterior margin corresponds to the crural arch; its posterior margin to the crest of the pubes; its outer margin is free, concave, tense, and sharp, and forms the inner part of the circumference of the crural ring (*r*). This concavity, against which the protruded intestine becomes strangulated, has obtained for the ligament the name of the *falciform ligament* or *fold*.* Its strength is very considerable; but occasionally intervals are left between its fibres, through which hernial protrusions may take place.†

From the lower surface of Gimbernat's ligament a fibrous prolongation is given off, which sometimes represents a second arch below the femoral arch, and assists in forming the superficial layer of the fascia lata of the thigh. This tendinous expansion has a great effect in rendering the arch tense. We may add, that there is considerable variation in different subjects, both in the strength and developement of Gimbernat's ligament; varieties that must have great influence on the position of crural herniæ, and on the seat of strangulation in that disease. Behind the femoral arch, on the outer side of Gimbernat's ligament, is an opening (*a* to *r*, *fig.* 136.) or ring, intended to give passage to the femoral artery (*a*) and vein (*v*), and to a great number of lymphatic vessels and glands: this is the *crural ring.*‡ The sub-peritoneal cellular tissue sometimes acquires great strength opposite this ring, and constitutes what is called the *crural septum* (situated at *r*). The form of the crural ring is that of an isosceles triangle, the base of which is very long, and formed by the crural arch, the inner border by the pectineus, and the outer by the psoas and iliacus muscles. Of the three angles the internal is rounded, and corresponds to the concave margin of Gimbernat's ligament; the external angle, opposite which the epigastric artery is situated, is very acute, and corresponds to the point at which the femoral arch separates from the iliac fascia; the posterior angle is very obtuse, and corresponds to the ilio-pectineal eminence (*d*).

The femoral vein is in relation with the inner or pectineal border of this triangular space; the femoral artery with the ilio-pectineal eminence and the

* [This term is now generally applied (after Burns) to the external margin of the saphenous opening (*n*, *fig.* 137.) in the fascia lata.]

† M. Laugier has lately recorded a case of hernia through the fibres of Gimbernat's ligament. I have since had an opportunity of seeing, in an old woman at the Salpêtrière, two hernial sacs near each other, one of which protruded through the crural ring, and the other internally to the ring; the necks of these sacs were separated by a fibrous band, which appeared to me to be formed by the external fibres of Gimbernat's ligament.

‡ [The term "crural ring," it must be remembered, is limited by British anatomists and surgeons to the small space (*r*), bounded internally by the free margin of Gimbernat's ligament, and externally by the femoral vein. It is through this space, and therefore through the internal portion only of the "crural ring" of M. Cruveilhier, that crural herniæ descend.]

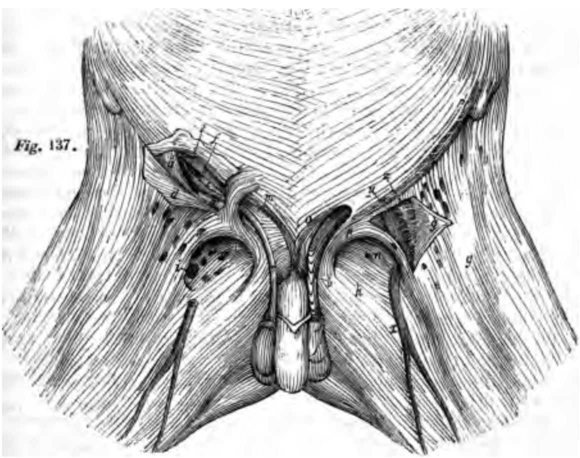
er border. The crural nerve (*n*) lies behind and externally to the artery, ng separated from it only by the iliac fascia (*s'*). Crural herniæ descend ough the inner portion of the crural ring. *

The femoral arch is formed by proper fibres, arising from the anterior su- ior spinous process of the ilium; and also by those fibres of the aponeurosis the external oblique, which, after having arrived at the arch, change their ection, become reflected inwards, and are collected together, so as to form a ong and tense cord.

The inguinal ring and canal. On the inner side of the spine of the os pubis, ween the spine and the symphysis, the aponeurosis of the external oblique ides into two almost parallel, or at least very slightly diverging, bands, ich leave between them an opening for the passage of the spermatic cord in male, and of the round ligament in the female. This opening is the *in- nal ring* (*m*, *figs.* 109. 136, 137.), and the bands which form its limits are led the *pillars* (*o p*, *figs.* 136, 137.). The inguinal ring is oval or trian- ar; its greatest diameter has the same direction as the fibres of the external ique, viz. obliquely downwards and inwards. Its base corresponds to the erval between the spine and symphysis pubis. Its apex is not always well ined, and is generally truncated by fibres which pass at right angles to its lars. From the upper part of the margin of the ring a tendinous prolong- on is given off, which accompanies the spermatic cord in the male, and the nd ligament in the female.

Of the pillars one is *external* or *inferior*, the other *internal* or *superior*. The *ernal pillar* (*p*) is attached, not to the spine of the os pubis, but into the e part of the symphysis: this pillar is nothing more than the internal ex- mity of the direct portion of the femoral arch. Moreover, some anatomists nsider Gimbernat's ligament as the reflected portion of the external pillar. e *internal pillar* (*o*) is broader than the external, and intersects the cor- ponding structure of the opposite side in front of the symphysis, not unfre- ently some fibres of the right internal pillar intersecting those of the left ernal pillar.

Fig. 137.



* See note, p. 398.

Inguinal canal or passage. The *inguinal ring* (*m*) is the anterior or cutaneous orifice of an oblique passage, formed in the substance of the lower edge of the inferior parietes of the abdomen opposite the crural arch, and destined to transmit the cord (*s*) of the spermatic vessels in the male, and the round ligament of the uterus in the female. This passage, which modern writers only have correctly described, has been styled by them the inguinal *canal* (*t c m*). Its length varies from an inch and a half to two inches and a half; it is directed obliquely downwards, forwards, and inwards.

The inguinal canal is formed in reality by the groove resulting from the reflection backwards of the aponeurosis of the external oblique (at *a*), the posterior border of which groove is continuous with the fascia transversalis, and its anterior border with the aponeurosis of the external oblique itself. We may then consider this passage as having an *inferior concave wall* (at *a*) formed by the groove of reflection; an *anterior wall*, formed by the aponeurosis of the external oblique (shown turned downwards at *d*); and a *posterior wall*, formed by the fascia transversalis (*c*). There is no *superior wall*, or rather it is supplied by the lower margins of the internal oblique (*e*) and transversalis (*f*) muscles, which occupy the groove of the crural arch, and receive from it externally numerous points of attachment. Internally the margins of these muscles are separated from the groove by the spermatic cord, or the round ligament. It has been supposed that this canal is lined by a funnel-shaped prolongation of the fascia transversalis. The *peritoneal* or *internal orifice* (*t*, *figs.* 110. 137.) of the inguinal canal is much less accurately defined than the external, or rather its inner border alone is well defined, consisting of a concave fibrous edge formed by the fascia transversalis, and somewhat analogous to the concave edge of Gimbernat's ligament. The strangulation of the intestine in inguinal hernia sometimes occurs against this edge. The peritoneal orifice of the inguinal canal is closed by the peritoneum, and the epigastric artery runs along its inner border.

The testicle, which is originally situated within the abdomen, descends through the inguinal canal; so also do those herniæ, commonly called oblique inguinal herniæ, in order to distinguish them from the direct or internal inguinal herniæ.

The anterior aponeuroses of the obliquus internus and transversalis. The *aponeurosis of the internal oblique* commences at the linea alba, and immediately divides in its upper three fourths into two layers, one of which passes in front, and the other behind the rectus (*r*, *fig.* 134.). The lower fourth passes entirely in front of the same muscle without division (as shown in *fig.* 135.). The *anterior layer* is very closely united with the aponeurosis of the external oblique (at *b*), from which it can be distinguished only by the direction of its fibres. In some parts there is even a true interlacement between the tendinous fibres of these two muscles; the lower or undivided portion of the aponeurosis of the internal oblique may, on the contrary, be easily separated from that of the external oblique. The *posterior layer* of the aponeurosis of the internal oblique is no less intimately blended with that of the transversalis (at *c*), from which, also, it is to be distinguished by the direction of its fibres only. At the outer border of the rectus muscle the anterior layer of the aponeurosis of the internal oblique separates from that of the external oblique, and the posterior layer from that of the transversalis, and then immediately unite together, and give origin to the fleshy fibres. The outer margin, therefore, of the aponeurosis of the internal oblique exactly corresponds to the outer border of the rectus, and is directed vertically.

The *aponeurosis of the transversalis* (*f*, *figs.* 134, 135.) is the deepest layer of the anterior abdominal aponeurosis: it is very narrow above, increases in breadth as far down as opposite the crest of the ilium, and then progressively diminishes towards its lower portion. It commences at the linea alba, and is divided into two portions,—one inferior (below *s*, *fig.* 110.), consisting only of

the lower fourth of the aponeuroses, and passing in front of the rectus (as in *fig.* 135.); the other superior (above *s*, *fig.* 110.), which passes behind the rectus (as in *fig.* 134.), and is formed by the upper three fourths of the aponeurosis. Its external margin is convex, and gives origin to the fleshy fibres of the muscle. Its anterior surface is closely united to the aponeurosis of the internal oblique, beyond which it passes on the outside: its posterior surface is loosely connected with the peritoneum, excepting in its lower fourth, which, as already stated, passes in front of the rectus muscle. The tendinous fibres of the transversalis, which have the same direction as its fleshy fibres, are occasionally found not to terminate abruptly behind the lower part of the rectus; but the aponeurosis merely becomes thinner, and its fasciculi separated from each other.

The Fascia Transversalis and Sub-peritoneal Aponeurosis.

In order to complete the description of the anterior abdominal aponeurosis, it only remains for me to describe the *fascia transversalis*, which I regard as a thickened portion of the *sub-peritoneal fascia*.

The *fascia transversalis* (seen at *a'* and *c*, *fig.* 137.) was first pointed out by Sir Astley Cooper, but has been more correctly described by Lawrence and J. Cloquet: it commences below at the reflected border (*a a'*) of the crural arch, so that it may be regarded as a thin prolongation of the reflected portion of the tendon of the external oblique. It also frequently arises from the brim of the pelvis, as well as from the crural arch. From these points it passes upwards, becoming more and more attenuated as it approaches the umbilicus, at which point it cannot be distinguished from the sub-peritoneal aponeurosis.

The fascia transversalis is situated between the abdominal muscles and the peritoneum. Its internal margin is continuous with the outer border of the rectus muscle; and its external margin, which gradually becomes thinner, is blended with the sub-peritoneal aponeurosis. The only part deserving a special description, is that portion which lies between the outer border of the rectus muscle and the abdominal opening of the inguinal canal. In this situation it assists in strengthening the parietes of the abdomen, which are here remarkably weak; and it is to the existence of this fascia that we may attribute the extreme rarity of direct inguinal herniæ *, which, in fact, can only result from a congenital weakness, or a relaxation of this fascia.

A very interesting portion of the fascia transversalis is an infundibuliform prolongation, given off from it to the spermatic cord. It is impossible, indeed, to conceive the descent of the testicle to occur without its pushing before it a portion of the fascia, which then constitutes the immediate investment of the cord, upon which the cremaster muscle (*b*, *fig.* 137.) is spread out. The peritoneal orifice of the inguinal canal is, therefore, the superior opening of the infundibuliform process, furnished by the fascia transversalis to the testicle and its cord.

The Sub-peritoneal Aponeurosis.

The peritoneum, throughout the whole extent of the abdominal parietes, is strengthened on its outer surface by a very thin tendinous layer, the existence of which may serve to explain why abscesses, formed in the parietes of the abdomen, so seldom open into the cavity of the peritoneum; and on the other hand, why collections within the peritoneal cavity so seldom open externally.

* [*I. e.* herniæ occurring *directly* downwards and forwards through the inguinal *ring* (*m*, *fig.* 137.), and not descending along the inguinal *canal*.]

The Posterior Abdominal Aponeurosis.

The *posterior abdominal aponeurosis* is much smaller and of less importance than the anterior: it consists of three layers, one *anterior* (*h*, in diagram, *fig.* 134.), and very thin, which commences at the base of the transverse processes of the lumbar vertebræ, and passes in front of the quadratus lumborum (*q*); another, *middle* (*i*), and much stronger, commencing at the summits of the same transverse processes, and passing behind the quadratus lumborum; and a third, *posterior* (*k*), which arises from the summits of the lumbar spinous processes, and passes behind the sacro-lumbalis, longissimus dorsi, and transverso-spinalis muscles (*s*). This last mentioned layer is connected both with the internal oblique (*e*) and with the transversalis muscles (*f*), and is blended with the aponeuroses of the serratus posticus inferior, and of the latissimus dorsi (*l*). The two anterior layers are connected with the transversalis only. The posterior abdominal aponeurosis has, therefore, nearly the same relation to the quadratus lumborum and the common mass of the sacro-lumbalis, longissimus dorsi, and transverso-spinalis muscles, that the anterior aponeurosis has to the rectus muscle.

The Lumbo-iliac Aponeurosis.

The *lumbo-iliac aponeurosis*, or *fascia iliaca* of modern authors, forms the tendinous sheaths of the abdominal portion of the psoas and iliacus muscles, and is therefore bifurcated at its upper part. That portion which invests the psoas commences at the tendinous arch of the diaphragm, already described as embracing the upper end of this muscle. The iliac portion arises from the whole extent of the inner border of the crest of the ilium. The circumflex ilii artery is situated in the substance of this iliac portion, at its origin. The internal margin of the fascia iliaca is attached to the sides of the lumbar vertebræ, and lower down to the brim of the pelvis: it is arranged in arches, which give passage to the lumbar vessels and to the nervous cords, establishing a communication between the lumbar plexus and the lumbar ganglia of the sympathetic nerve. The centre of each arch is opposite to the groove on one of the bodies of the lumbar vertebræ, the intervals between the arches corresponding with the intervertebral substance. The largest arch extends from the last lumbar vertebra to the brim of the pelvis, and is opposite to the base of the sacrum. The obturator and lumbo-sacral nerves pass under it.

Opposite the femoral arch, the fascia iliaca adheres intimately to the *outer* part of Poupart's ligament; but towards the median line it separates from that ligament, passes behind the femoral vessels, and forms the posterior half (*s*, *fig.* 136.) of the crural ring.

Below the femoral arch, the fascia is prolonged upon the thigh; on the outside (*s′*) it completes the sheath of the psoas and iliacus, accompanies them as far as the lesser trochanter, and becomes continuous with the iliac portion (*g*, *fig.* 137.) of the femoral fascia; on the inside, it forms the posterior wall (*s*, *fig.* 136.) of the canal for the femoral vessels, and forms the deep layer or pubic portion (*h*, *fig.* 137.) of the femoral fascia.

Relations. It lies beneath the peritoneum, to which it is united by a very loose cellular tissue: it covers the psoas and iliacus, but is not adherent to them, in consequence of the interposition of some equally delicate cellular tissue. All the nerves from the lumbar plexus are subjacent to this fascia, excepting one very small cord, which perforates it at the side of the sacrum, and becomes situated in the sub-peritoneal cellular tissue. The femoral vessels are situated on the inner side of the fascia, and are separated by it from the crural nerve, which lies on its outer side, and underneath it.

Structure. The upper part of the fascia is extremely thin, but it increases in thickness as it approaches the femoral arch. It is formed of well marked transverse fasciculi, intersected perpendicularly by the tendon of the psoas parvus, when that muscle exists. This tendon is blended with the fascia, and

is distinguished from it only by the different direction of its fibres; it is inserted by spreading out at the side of the pelvic brim into a tendinous arch which lines this brim, and with which the psoas parvus and the iliac fascia are continuous above, and the pelvic fascia below.

Few aponeuroses are more deserving the attention of anatomists than this, on account of the practical consequences resulting from its arrangement. In fact, notwithstanding its tenuity, it forms a boundary between the sub-peritoneal and sub-aponeurotic cellular tissue, which is very rarely passed by inflammatory action. When inflammation terminates in suppuration, the pus, whether it be beneath the peritoneum, or beneath this fascia, descends towards the femoral arch; but if the inflammation be sub-peritoneal, the femoral vessels lie behind the purulent collection; and should it be sub-aponeurotic, the vessels will be in front of it. The latter is especially the case in abscesses, following caries of the vertebræ.

The Aponeuroses of the Pelvis.

The *aponeuroses of the pelvis* should be distinguished into the *pelvic*, properly so called, and the *perineal*: the former constitute essential parts of the pelvis, and are deeply seated. The others belong to that part of the floor of the pelvis which is called the perineum. I shall commence with the description of the latter.

The Aponeuroses of the Perineum.

These are two in number, — one *superficial*, the other *deep*.

*The Superficial Perineal Fascia.**

Dissection. Remove the subcutaneous adipose tissue very cautiously, layer by layer, commencing the dissection along the edges of the pubic arch.

This aponeurosis (which is very distinct from the fibrous laminæ, intercepting spaces filled by fat, and forming what is called the fascia superficialis), is of a triangular shape, and consists of well marked transverse fibres. The *outer margin* of each half of the fascia is attached to the descending ramus of the os pubis and the ascending ramus of the ischium: its *inner margin* is lost at the raphé, along the median line: its *posterior margin* is bounded by a line, extending from the tuberosity of the ischium to the anus; it corresponds with the posterior edge of the transversus perinei muscle, and appears to be reflected behind it, so as to line the corresponding perineal or ischio-rectal fossa.†

Relations. It is covered by a prolongation of the dartos, to a greater extent in the median line than on each side; also by the subcutaneous adipose tissue, which is thicker behind than in front, and by the sphincter ani, above which it terminates in the median line: it covers the transversus, the bulbo-cavernosus, and the ischio-cavernosus muscles, the fibrous sheaths of which may even be regarded as a prolongation of this aponeurosis. It also covers the superficial perineal vessels and nerves, which are sometimes lodged within its substance. The existence of this membrane explains why, in cases of perforation of the urethra, the urine is infiltrated forwards, and very rarely backwards.

The Deep Perineal Aponeurosis.

Dissection. Remove with great care the ischio- and bulbo-cavernosus and the transversus perinei muscles.

This aponeurosis, which was well described by M. Carcassone under the name of *perineal ligament*, and called by modern writers the middle perineal fascia, appears to me perfectly distinct from the aponeuroses of the pelvis. It

* M. Bouvier in his thesis, and M. Blandin in his *Traité d'Anatomie Chirurgicale*, first described this fascia.

† See note, p. 406.

is an extremely strong triangular layer (*b a*, *fig.* 138.*), occupying the pubic arch and apparently forming a continuation of the sub-pubic ligament (*b*). It is vertical near the arch, as far as the ball of the urethra, below which it becomes horizontal, or rather oblique, from before backwards. Its *lateral margins* are attached to the descending rami of the ossa pubis, and the ascending rami of the ischia (*d d*), above the

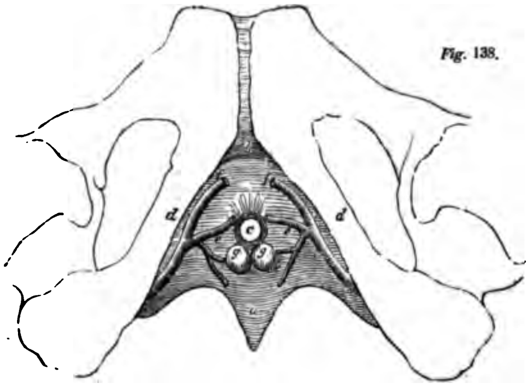


Fig. 138.

attachment of the ischio-cavernosi muscles. Its *posterior margin* becomes blended with the posterior margin of the superficial perineal fascia, behind the transversi muscles, in front of the perineal fossæ, of which it forms the anterior boundary.

Relations. Its lower surface is in relation with the ischio- and bulbo-cavernosus muscles, and gives off in the median line a fibrous septum, which passes between these muscles, and affords them points of attachment. Its upper surface is in relation with the artery or arteries (*e e*) of the bulb, which are sometimes contained within its substance: it is also in contact with a very remarkable plexus of large veins, with which it is very closely united, so that when divided they remain open: these veins are also frequently enclosed within its substance. It is also in relation with the levator ani.

There constantly exists another transverse muscle, very distinct from the transversus perinei generally described, which is situated further behind. This muscle (transversus perinei alter, *Alb.*) is applied to the lower surface of the perineal fascia, and passes transversely inwards to the bulbous portion of the urethra.

The deep fascia of the perineum is perforated (at *c*) by the posterior part of the bulb of the urethra, or rather by the point of union (*c*, *fig.* 181.) between its bulbous and membranous portions: it gives off prolongations upon the sides of the bulb, and serves to support the membranous portion of the urethra: whence the name, *triangular ligament of the urethra*, given to it by Colles. It is also perforated beneath the arch of the pubes by a great number of veins, and by some arteries.

Uses. This remarkable aponeurosis evidently supports the canal of the urethra. It has been correctly regarded as an obstacle to the introduction of the catheter, the point of which strikes against it, however slightly it may deviate from the direction of the canal. The prostate gland is situated above it.

The Pelvic Aponeuroses.

From the sides of the pelvis, and from the entire circumference of the brim (which, as we have seen, is covered and rendered smooth by a thick layer of fibrous tissue, that forms a limit to the lumbo-iliac aponeurosis), a tendinous la-

* [The triangular ligament consists of two layers which approach each other, more nearly above than below: in *fig.* 138. the anterior layer has been removed. Between the two layers are situated the sub-pubic ligament (*b*), perforated by the venæ dorsales penis, the pudic arteries (*f f*), the arteries of the bulb (*e e*), the greater part of the membranous portion of the urethra, with its compressor muscle to be described hereafter, and lastly Cowper's glands (*g g*). In the female the triangular ligament is perforated by the vagina, as well as by the urethra.]

mina is given off, which passes into and lines the pelvis, and is soon divided into two distinct layers: one *external*, the *lateral pelvic* or *obturator fascia*, which continues to line the sides of the pelvis, and covers the obturator internus muscle; the other *internal*, or superior, which passes inwards upon the side of the prostate gland, bladder, and rectum in the male, and of the bladder, vagina, and rectum in the female, in order to form the floor of the pelvis. This is the *superior pelvic aponeurosis*, with the description of which we shall commence.

The Superior Pelvic Aponeurosis, or Recto-vesical Fascia.

Dissection. This aponeurosis must be studied both from the cavity of the pelvis and from the perineum. It is exposed in the pelvis by removing the peritoneum, and the loose cellular tissue beneath that membrane: this should be done without any cutting instrument. To view this fascia from the perineum, it is necessary to take away the adipose tissue that occupies the perineal fossæ, and also the levator ani muscle.

The *superior pelvic aponeurosis* forms a complete floor for the pelvis. Anteriorly it is remarkable for its strength and shortness; in fact, it does not reach the inlet in this situation, but arises on each side from the symphysis pubis, presenting the appearance of bands or columns, which are more or less separated from each other, and become attached to the front of the neck of the bladder, whence the name of *anterior ligament of the bladder*, which the older anatomists gave to this part of the aponeurosis. *More externally* it forms a strong arch (the *sub-pubic arch*), which completes the posterior orifice of the obturator or sub-pubic canal (*i*, *fig.* 48.). This arch is not unfrequently double, and then one of the foramina gives passage to vessels, and the other to nerves.

Still *more externally* it is attached to the brim of the pelvis, in the manner I have already pointed out.

Posteriorly it is extremely thin, passes in front of the sciatic plexus, and is lost upon the sacrum. Sometimes it appears to be divided into two laminæ, the posterior of which passes in front of the sciatic plexus, and the anterior in front of the internal iliac vessels, to which it would seem to furnish sheaths.

Relations. Its *upper* surface is concave, and connected with the peritoneum by loose cellular tissue, containing more or less fat. Its *lower* surface is convex, and covered by the levator ani: it forms part of the great perineal excavation, and is in relation with the pyriformis and obturator internus muscles, with the sacral plexus, &c.

This aponeurosis is perforated by a great number of openings: in the male it is pierced by the prostate (*i*, *fig.* 181.) and the bladder (*h*), on the sides of which it is prolonged and reflected on to the rectum, whence the name of the *recto-vesical aponeurosis*, given to it by M. Carcassone. In the female it is also perforated by the vagina. On each side of the bladder and prostate it is strengthened by two tendinous bands, which run from before backwards. These are sometimes very strong; they extend from the symphysis pubis (*b*), to the spine of the ischium (*e*), pass along the bladder and the prostate, and are reflected upon their sides.

In front, it has some openings for the vesical and prostatic vessels.

Behind, it presents a considerable opening, which corresponds to the outlet of the pelvis, and gives passage to the lumbo-sacral nerve and the gluteal vessels. The extremity of the arch formed by it corresponds to the anterior border of the sciatic notch. It is through this opening that sciatic herniæ protrude.

We not uncommonly find larger or smaller openings in this fascia, of an oblong or circular shape, leading into conical culs-de-sac, which are filled with fat. Lastly, it is perforated behind by the ischiatic and internal pudic vessels. It does not appear to be intended for the passage of the vessels which are distributed in the interior of the pelvis, for it seems to invest these in fibrous sheaths.

Uses. The superior pelvic aponeurosis forms the floor of the pelvis; it is pushed downwards by the action of the diaphragm and abdominal muscles, and tends to prevent the occurrence of perineal herniæ, which otherwise would be extremely common: it forms a boundary between the sub-peritoneal and the perineal cellular tissue, and also limits the progress of inflammation and infiltrations. Infiltration of urine above the fascia can only be caused by rupture of the bladder itself. The prostate (*i, fig.* 181.) is almost entirely below the fascia, and therefore in the lateral operation for stone, in which this gland is the principal structure to be divided, inflammation and infiltration of the cellular tissue are extremely rare. When they do occur, the section or laceration must have been prolonged into the body of the bladder.

The Lateral Pelvic Aponeurosis, or Fascia of the Obturator Muscle.

Dissection. This aponeurosis is more advantageously studied, at least in its most important part, from the perineum, than from the cavity of the pelvis: it is exposed on either side by removing the adipose tissue, which fills up the perineal fossa. This aponeurosis, which is quite distinct from the obturator ligament, commences at the upper part of the circumference of the obturator foramen and at the brim of the pelvis, in connection with the superior pelvic aponeurosis, which it soon leaves, and is applied to the obturator internus muscle; it then unites below with the reflected portion of the great sacro-sciatic ligament, and is prolonged upon that portion of the anterior surface of the glutæus maximus which projects beyond the ligament, and also upon the coccygeus muscle.

Relations. On the inner side and above it is only separated from the superior pelvic aponeurosis by the levator ani, which is applied to that aponeurosis; lower down, the two aponeuroses are separated by a considerable interval, which is occupied by fat: this interval forms the *perineal fossa.* On the outside it is in contact with the obturator internus, and lower down with the internal pudic vessels and nerves.

Uses. It binds down the obturator internus muscle, and protects the internal pudic vessels and nerves, which are therefore rarely cut in operations in the perineum. It forms the external boundary of the perineal fossa.

The perineal fossæ. Situated between the superior pelvic aponeurosis (which is lined below by the levator ani) and the lateral pelvic aponeurosis, there is found on each side of the anus a conical space, the base of which is directed downwards, and corresponds to the skin: it is formed behind by the lower border of the glutæus maximus; in front by the transversus perinei muscle; on the inside by the levator ani and the superior pelvic aponeurosis; and on the outside by the tuberosity of the ischium.* Each of these fossæ is filled by a large quantity of fat, and traversed by fibrous laminæ, some of which extend vertically from the apex to the base, and divide the contained adipose cellular tissue into several distinct portions. When an abscess occurs in either of these fossæ, it may be easily conceived, how difficult it is for the inner surface of its parietes to come into opposition: hence the pathology of fistulæ, and the modes of cure which are adopted.

THE APONEUROSES OF THE LOWER EXTREMITY.

The aponeuroses of the lower extremity comprise, the *femoral fascia*; the *fascia of the leg*; the *annular ligaments*, which bind down the tendons of the

* [These spaces are the *ischio-rectal fossæ* of Velpeau; they are described by him as if lined by an aponeurosis (the ischio-rectal) composed of two layers, one external or ischiatic, corresponding to the *lateral* pelvic aponeurosis of M. Cruveilhier, and another internal or rectal, which covers the lower surface of the levator ani from the coccyx to the posterior border of the transversus perinei, and unites with the other layer before, above, and behind. This latter layer is very thin, and continuous with the united margins of the superficial perineal fascia and the triangular ligament, behind the transverse muscle, and is alluded to by M. Cruveilhier (p. 403.) as a reflection of the superficial fascia.]

muscles of the leg, as they are passing upon the dorsal or plantar surface of the foot; *the plantar* and *dorsal fasciæ* of the foot; and, lastly, the fibrous *sheaths*, which maintain the tendons in contact with the phalanges of the toes. We shall describe these in succession.

The Femoral Aponeurosis, or Fascia Lata.

After the remarks which we have already made upon the aponeuroses generally, it may be easily conceived that the muscles of the thigh, which are so numerous, of such great length, and so loosely united together, and almost all of which are reflected to a greater or less amount over the knee, require to be kept in close contact with each other and with the bones; hence the necessity for the *femoral aponeurosis*, consisting of a large fibrous sheath, that confines without compressing the muscles, and the strength of which is directly proportioned to the force of the muscles, and their tendency to displacement. Its superficial or subcutaneous surface (*g h*, *fig.* 137.) is separated from the skin by a very thin fibrous layer, the *fascia superficialis* (not shown in *fig.* 137.), which can be more easily demonstrated immediately below the femoral arch, and along the saphenous vein. Between the femoral aponeurosis or fascia lata and this superficial fascia, which results from the union of the fibrous prolongations given off by the deep surface of the skin, the subcutaneous vessels and nerves take their course, and communicate with the deep vessels and nerves, either by simple openings or by fibrous canals, of variable length. Under this fascia also are situated the superficial lymphatic vessels, and glands of the groin.

A great number of the superficial nerves of the thigh have special sheaths, which are hollowed out, as it were, in the substance of this aponeurosis.

The femoral aponeurosis is perforated with a great number of foramina opposite the femoral vessels, from Poupart's ligament to the entrance of the vena saphena (*x*) into the femoral vein (*y*). These foramina, which occupy a triangular space, of which the base is above and the apex below, are intended for the passage of a great number of lymphatic vessels, which pass through it to join the deep set. This has been called the *sieve-like portion* of the fascia lata, or the *fascia cribriformis* (*v*): it has been said by some, that the aponeurosis is altogether wanting in this situation.* We not unfrequently find a lymphatic gland occupying one of the foramina.

The most remarkable of all these openings is undoubtedly that (*i*) for the vena saphena interna, where that vessel enters the femoral vein, at the upper part of the thigh, eight or ten lines below Poupart's ligament. The margin of this opening, which has been improperly called the *inferior orifice of the crural canal*, can only be demonstrated in its lower half, on account of the almost complete absence of the aponeurosis above it: this is the reason of the semilunar form of the portion of the fascia over which the vein passes.

The *deep surface* of the fascia lata gives off a great number of prolongations, which pass between the muscles, and form their proper investments or sheaths.

The largest of these prolongations form two lateral septa, called the *intermuscular septa*, which extend from the fascia to the linea aspera; each has the form of a triangle, having its base directed downwards and its apex upwards; they are extremely thick, especially below.

The Intermuscular Septa of the Femoral Aponeurosis.

Of these there are two, one *internal* and the other *external*.

The *internal intermuscular septum*. This serves at once as a septum, an aponeu-

* [And *then* the cribriform fascia is regarded, not as belonging to the fascia lata, but as formed by a *deep* layer of the superficial fascia, situated *beneath* the subcutaneous vessels, adherent to the borders of the saphenous opening in the fascia lata, and perforated by those vessels. The saphenous opening is, according to this view, not the foramen (*i*) through which that vein passes, but the aperture (*n*) left between the iliac (*g*) and pubic (*h*) portions of the fascia lata, and is bounded externally by the crescentic margin of the iliac portion, or the falciform process of Burns (see the left side of *fig.* 137. where the cribriform fascia has been entirely removed).]

rosis of insertion, and a sheath for the vastus internus: it extends from the anterior inter-trochanteric line to the inner condyle of the femur.

Its anterior surface affords attachments to the vastus internus, throughout its whole extent: its posterior surface is in opposition with the adductors, and is intimately united to their aponeuroses. Its outer margin is attached to the linea aspera: its inner margin is very thick, and prominent below, where it is strengthened by the inferior tendon of the adductor magnus, and may be felt under the skin like a cord. It appears to become continuous below with the internal lateral ligament of the knee.

It is composed of very strong vertical fasciculi, passing somewhat obliquely downwards and inwards. These fasciculi are bound together above the inner condyle by others passing transversely, and are crossed almost at right angles by the tendinous fibres of the adductors.

Lastly, the internal septum is perforated, near the linea aspera, by a number of orifices destined for the passage of vessels, and forming communications between the anterior and the internal sheath of the muscles of the thigh.

The external intermuscular septum. This serves as a septum, an aponeurosis of insertion, and as a sheath for the vastus externus.

It extends from the great trochanter to the external condyle, above which it forms a projecting cord: it affords attachments to the vastus externus in front, and to the short head of the biceps behind. Its inner margin is attached to the linea aspera: its outer margin forms a prominent cord, especially below.

It consists of fibres directed vertically, or somewhat obliquely outwards, and strengthened by transverse fibres above the condyle. Like the internal septum it is perforated, especially above and below: above, for the passage of the circumflex vessels; below, for the passage of the articular vessels of the knee.

We shall now examine the different sheaths furnished by the femoral aponeurosis. One of the most important of these is, as it were, hollowed out of the sides of the others, and belongs to the femoral vessels.

The Sheath of the Femoral Vessels.

The femoral artery (*z*, *fig.* 137.) and vein (*y*) are inclosed in a prismatic and triangular tendinous canal, which protects them in their course amidst the muscles of the thigh. The portion of the canal (laid open in *fig.* 137.), included between the femoral arch and the point where the vena saphena opens into the femoral vein, has received the name of the *crural canal*, a term to which I have always objected, since it was first introduced into anatomical nomenclature, because it establishes a false analogy between the inguinal canal and this upper portion of the sheath of the femoral vessels; for, while an oblique inguinal hernia traverses the entire length of the inguinal canal, crural herniæ, as far at least as my own observation extends, never protrude through the saphenous opening, but escape immediately below the femoral arch, and lift up the cribriform portion of the fascia lata.*

The *anterior wall* of the sheath of the femoral vessels is formed above by the cribriform portion of the femoral fascia (*g'*, *fig.* 137.), then by the fascia itself, and lastly by the posterior layer of the sheath of the sartorius, in which place it is thin and transparent.

The *internal wall* is formed above by the very strong layer covering the pectineus, below by the weaker layer investing the adductors.

* [The term "crural ring" is, in this country, commonly limited to the space (*r*, *fig.* 136.), situated internally to the femoral vein. By the term "crural canal," is generally understood that portion only of the canal described by M. Cruveilhier as the "crural canal," which is situated on the *inner side* of the femoral vein, and is occupied by cellular tissue, lymphatic vessels, and sometimes by a lymphatic gland. If the term crural canal be thus defined, if the cribriform fascia be regarded as a part of the superficial fascia, and the saphenous aperture as the space between the iliac and pubic portions of the fascia lata (see note, p. 407.), the analogy between the crural and inguinal canals will not be so very remote.]

The *external wall* consists of the very strong sheath (*s'*, *fig.* 136.) of the psoas and iliacus: externally to this wall is situated the crural nerve, a branch of which perforates the sheath, and joins the vessels. Lower down, the external wall is formed by the aponeurosis of the vastus internus.

The Three Great Muscular Sheaths of the Femoral Aponeurosis.

By means of the internal and external inter-muscular septa, the muscles of the anterior region of the thigh are separated from those of the posterior and internal regions; a weaker septum than the preceding intervenes between the muscles of the internal and posterior regions. It follows, then, that the femoral aponeurosis presents three great tendinous sheaths, — an *anterior*, an *internal*, and a *posterior*.

The *great posterior sheath* is undivided: it is common to the biceps, the semi-tendinosus and the semi-membranosus.

The *great anterior and internal* sheaths are subdivided into a number of secondary sheaths, in most cases corresponding with the number of the muscles.

The great anterior sheath. The sartorius has a proper sheath, remarkable for its prismatic and triangular form. The rectus femoris, or long head of the triceps, is separated from the two vasti by a tendinous layer, very thin below, but strong above, and composed of vertical fibres.

The tensor vaginæ femoris is contained in the strongest sheath in the human body, for it is formed by the fascia lata itself. The deep layer of this sheath is much thinner than the superficial; it commences at the anterior inferior spinous process of the ilium below the rectus, and may be regarded as the deep origin of the broad band in which the tensor vaginæ femoris terminates: it is composed of vertical fibres, prolonged between the rectus and the vastus externus. Lastly, above and on the outside, we find the sheath of the psoas and iliacus (*s'*, *fig.* 136.), which forms a continuation of the lumbo-iliac aponeurosis, or fascia iliaca.

The *great internal sheath* furnishes a number of tendinous lamellæ, which separate the different muscles of this region. Thus, there is a proper sheath for the gracilis, a common one for the pectineus and the adductor longus, one for the adductor brevis, and another for the adductor magnus. The sheath of the obturator externus is continuous with that of the adductor brevis; it commences by a very strong fibrous lamina or arch, which arises from the anterior edge of the pubes, and is directed obliquely outwards to the fibrous capsule of the hip joint. This arch conceals the anterior orifice of the obturator canal, and protects the obturator vessels and nerves.

Lastly, the two vasti, which extend into all the regions of the thigh, have sheaths formed by the femoral fascia, where they are superficial, and by the internal and external intermuscular septa, and the posterior laminæ of the other sheaths, in their more deeply situated portions.

In the midst of the sheaths of the anterior and internal regions, we find the sheath of the femoral vessels already described.

The Superior Circumference of the Femoral Aponeurosis.

In *front* the femoral aponeurosis arises from the femoral arch, with which it is so perfectly continuous, as to render the arch tense: hence the plan, already mentioned as proposed by Scarpa, of endeavouring to remove the constriction in cases of strangulated crural hernia, by puncturing the femoral aponeurosis.

But the mode of origin and continuity of this fascia with the femoral arch is not the same on the inner and outer sides. On the *outside* the *iliac portion* of the femoral aponeurosis (*g*, *fig.* 137.) arises by a single very thick layer; more *internally*, in the situation of the femoral vessels, it arises by two layers, one *superficial*, thin and perforated by foramina (the cribriform portion, *v*): the

other deep, called its *pubic* portion (*h*), which is continuous with the fascia iliaca (*s*, *fig.* 136.), covers the pectineus, and sends off a prolongation between that muscle and the psoas. This deep layer forms the posterior wall of the canal of the femoral vessels.

On the *inside* of the thigh, the femoral aponeurosis arises from the body of the os pubis, and the ascending ramus of the ischium.

On the *outside and behind*, it arises from the crest of the ilium by very numerous vertical fibres, which are strengthened, especially behind, by other horizontal fibres. Between the posterior superior spine of the ilium and the crest of the sacrum, there is a tendinous arch, which is common to the femoral fascia and the aponeurosis of the long muscles of the back.

The Glutæal Aponeurosis.

The glutæal aponeurosis forms the upper and back part of the femoral fascia. It covers the glutæus medius, in which situation it is extremely thick, and is continuous with the broad band of the tensor vaginæ femoris. Having reached the upper border of the glutæus maximus, it is divided into two layers,—one superficial and very thin, which covers the outer surface of the glutæus maximus, becomes thinner below, and continuous with the femoral fascia; the other deep and thicker, especially above and behind, where it affords attachment to the glutæus maximus, and is blended with the great sacro-sciatic ligament. It becomes very thin where it separates the glutæus maximus from the deep-seated muscles. A synovial capsule intervenes between this fascia and the great trochanter, and another between it and the tuberosity of the ischium.

It presents a very remarkable opening, called the *glutæal arch*, for the passage of the glutæal vessels and nerves. Lastly, over that portion of the glutæus maximus which enters into the formation of the corresponding perineal fossa, it acquires a great degree of thickness; and, at the lower border of the muscle, is blended with the superficial layer of the glutæal fascia.

The Inferior Circumference of the Femoral Aponeurosis.

The femoral aponeurosis terminates below, around the knee joint, where it becomes continuous, partly with the fascia of the leg, and partly with the fibrous structures covering this articulation. Concerning the arrangement of these fibrous laminæ, we shall offer a few remarks.

Behind, the femoral aponeurosis passes over the popliteal space, and is continuous with the fascia of the leg.

In front it is prolonged over the patella, from which it is separated by a synovial bursa; it is very thin, and is continued in front of the ligament of the patella, upon which it forms a thin layer of transverse fibres.

On the inside it is at first blended with the sheath of the sartorius, and then with the horizontal portion of the tendon of this muscle; it crosses the fibres of that portion perpendicularly, and becomes continuous with the fascia of the leg.

Under this layer of fibrous tissue we find, on the inside of the knee, another very dense layer, formed by vertical tendinous fibres derived from the vastus internus, and inserted into the upper part of the inner surface of the tibia, beneath the tendon of the sartorius. This fibrous layer, which may be regarded as the lower or tibial insertion of the vastus externus, occupies the interval between the internal lateral ligament of the knee joint and the patella. Its vertical fibres are crossed by others at right angles, extending from the internal tuberosity of the femur to the corresponding margin of the patella.

Lastly, under this we find another very thin layer, belonging to the synovial capsule

On the outside the femoral aponeurosis is blended with the broad band of

the tensor vaginæ femoris, from which it can be distinguished only by the horizontal direction of its fibres.

Beneath this very thick layer we find a thin one, composed of fibres stretching from the external tuberosity of the femur to the patella; and, lastly, another thin layer belonging to the synovial membrane.

Structure of the Femoral Aponeurosis.

It is thin behind and on the inside, thicker in front, and extremely thick on the outside of the thigh, where indeed it may be said to exceed all other fibrous membranes in thickness and in strength. This thickened portion is bounded in front by a line extending vertically downwards from the anterior superior spinous process of the ilium. Its limits behind are no less distinctly defined: hence the name given to it of *the broad band* (*fascia lata*).

This great density is owing to some very strong vertical fibres, arising from the front of the crest of the ilium. It is connected with the great force and tendency to displacement of the vastus externus.

We may add, that the femoral aponeurosis is composed of horizontal fibres, sometimes regularly parallel, as in its thinnest portions, and sometimes intersecting each other. These horizontal fibres are even seen opposite the broad band on the outer side, from which they are distinguished by their direction.

There is a very beautiful preparation of this aponeurosis in the museum of the Faculty of Medicine: similar preparations should be made by those who wish to obtain a good idea of the tendinous sheaths and the shape of the muscles of the thigh. It is to be made by removing all the muscles from their sheaths by means of longitudinal incisions, and substituting for them a quantity of tow, which must be taken out when the aponeuroses are completely dried. The form of the sheaths exactly represents that of the corresponding muscles. A tolerably accurate idea of these sheaths may also be obtained by cutting across each sheath and the muscle which it contains, in a fresh subject. The circumference of the section of the portion of the sheath that becomes visible after the retraction of the muscle, will give an excellent idea of the figure of the different sheaths, which are all angular and polyhedral like the muscles, but never rounded: during health they are completely filled by the muscles, which in emaciated persons, on the contrary, do not occupy more than a half, a third, or a sixth, of the area of their sheaths.

Such is the femoral fascia. Its tensor muscles consist of the tensor vaginæ femoris and the glutæus maximus, the tendon of which is received between two layers of this fascia.

Aponeuroses of the Leg and Foot.

Aponeurosis of the Leg.

The *aponeurosis of the leg* forms a strong general investment for the whole leg, excepting the internal surface of the tibia, which is covered by it only at its lower part, a little above the malleoli.

Its *external surface* is separated from the skin by the superficial vessels and nerves, several of which perforate it, either directly, or after having run for a short distance in its substance. The external saphenous vein and nerve receive from it a complete sheath.

Its *internal surface* covers all the muscles of the leg, and does not adhere to them excepting above and in front, where it gives attachment to the tibialis anticus and the extensor communis digitorum. From the internal surface there proceeds on the outer side of the leg, two principal tendinous septa, one situated between the muscles of the anterior tibial region and the peronei, the other between the peronei and the muscles of the posterior region of the leg. There are therefore three principal sheaths in the leg,—an anterior, an internal, and a posterior. The latter is subdivided into two other sheaths by a

very strong transverse lamina, becoming still stronger below, which separates the muscles of the deep posterior layer and the posterior tibial and peroneal vessels and nerves from the superficial layer of muscles, or the triceps suralis. Lastly, some tendinous laminæ, more or less complete, are interposed between the different muscles of each region. Thus a tendinous layer separates the tibialis anticus, at first from the extensor communis digitorum, and then from the extensor proprius pollicis: this layer disappears in the middle of the leg. Another very strong tendinous lamina separates the tibialis posticus from the flexor longus digitorum on the one hand, and from the flexor longus pollicis on the other.

Superior circumference. If we now examine the manner in which the aponeurosis of the leg becomes continuous with that of the thigh, we shall find that, posteriorly, the femoral fascia is prolonged directly upon the leg, in order to form the posterior part of its aponeurosis, which in this situation also receives an expansion from the tendons of the biceps, sartorius, gracilis, and semi-tendinosus, and from the broad band of the fascia of the thigh. *Anteriorly* the fascia of the leg is continuous with that of the thigh over the patella, and appears also to arise directly from the outer edge of the anterior tuberosity of the tibia, from the head of the fibula, and from the tendon of the biceps, which, as we have already seen, gives off an aponeurotic expansion backwards.

By its *lower circumference* this fascia is continuous with the annular ligaments of the ankle, which we shall presently describe.

Structure. On examining the direction of the fibres and the thickness of the fascia of the leg, it is found that it is much thicker in front than on the outer side of the leg, and still more so than behind; that, in the first situation, in the *upper* three fourths of its extent, it is composed of obliquely interlaced fibres, some of which descend from the spine of the tibia, and others from the anterior angular surface of the fibula; and that in the lower fourth of the anterior region of the leg, and in the whole extent of the posterior region, it is composed of circular fibres.

At the point where the muscles of the leg become tendinous, and are reflected over the ankle, they require very strong sheaths to keep them in contact with the joint; the fascia of the leg, therefore, forms opposite this part the *anterior, internal,* and *external, annular ligaments.*

The Annular Ligaments of the Tarsus.

The annular ligaments of the tarsus are three in number,—an *anterior* or *dorsal,* an *internal,* and an *external.*

The *dorsal annular ligament of the tarsus.* The aponeurosis of the leg is thicker at the lower and anterior part of the leg, and binds down the corresponding portion of the muscles in that region. But there is in addition to this a dorsal annular ligament of the tarsus (see *fig.* 128.), which arises, by a narrow but thick extremity in front of the astragalo-calcanean fossa, becomes broader as it extends inwards, and is divided into two bands. The *superior* band passes upwards and inwards above the internal malleolus, and is split into two layers, in such a way as to form two complete sheaths,—one internal, for the tibialis anticus; the other external, for the extensor longus digitorum and the peroneus tertius. Between these two complete sheaths, which are separated from the synovial capsule of the joint by a layer of cellular tissue, we find an incomplete sheath (for the annular ligament is not split into two layers in this situation), intended for the extensor proprius pollicis and the anterior tibial vessels and nerves: the internal sheath is the higher, and situated opposite the lower extremity of the tibia; the external sheath is lower, and corresponds to the ankle joint. The *inferior band,* or the lower bifurcation of the annular ligament, passes forwards and inwards to the front of the tarsus, and becomes continuous with the internal plantar aponeurosis. This lower band forms a second annular ligament, which furnishes to each of the

three preceding muscles, upon the dorsum of the foot, a less powerful sheath than that afforded by the upper band; it keeps the tendons closely applied to the bones.

The *external and internal annular ligaments* of the tarsus are two fibrous bands continuous with the fascia of the leg on the one hand, and with the plantar aponeurosis on the other.

The *internal annular ligament* arises from the borders and summit of the internal malleolus, and proceeds in a radiating manner to the inner side of the os calcis, and the inner margin of the internal plantar aponeurosis. Beneath this sheath, which is thicker below than above, and closes in the concavity on the inner surface of the os calcis, proceed the posterior tibial vessels and nerves, and also the tendons of the tibialis posticus, the flexor longus digitorum, and the flexor longus pollicis. For these several parts there are four very distinct sheaths: the most superficial is that for the vessels and the nerves: two sheaths, placed one over the other (see *fig.* 130.), and behind the internal malleolus, belong, the anterior to the tibialis posticus (*n*), and the posterior or more superficial to the flexor longus digitorum.(*o*) These two sheaths soon separate as the two tendons diverge from each other towards their insertions: as the sheath of the tibialis posticus is continued as far as the insertion of that muscle, the sheath of the flexor longus digitorum accompanies it to where it gets beneath (*i. e.* deeper from the surface than) the plantar fascia. The sheath of the flexor longus pollicis (*p*) is lower than the preceding, and extends obliquely along the astragalus and os calcis, to be covered by the internal plantar fascia.

The *external annular ligament* forms a common sheath for the two peronei, longus et brevis: it extends from the border of the external malleolus to the os calcis, and is completed on the inside by the external lateral ligaments. It is at first single, but soon becomes subdivided into two other sheaths, one of which is destined for the tendon of the peroneus brevis, and the other for that of the peroneus longus.

The Aponeuroses of the Foot.

These are divided into the *dorsal* and *plantar*.

The Dorsal Aponeuroses of the Foot.

These comprise the *dorsal aponeurosis* properly so called, the *pedal aponeurosis* (*l'aponeurose pédieuse*), and the *dorsal interosseous aponeuroses.*

Dorsal aponeurosis of the foot. While the upper margin of the annular ligament is blended with the fascia of the leg, which appears to be inserted upon it, the anterior margin of the same ligament becomes continuous with the dorsal aponeurosis of the foot. This dorsal aponeurosis is a thin layer, which forms a general sheath for all the tendons situated upon the dorsum of the foot: it gradually disappears in front, opposite the anterior extremities of the metatarsal bones, and is attached at the sides to the borders of the foot, becoming continuous with the plantar fascia. These tendons again are separated from the extensor brevis digitorum by another and still thinner layer, which invests that muscle: this is the *pedal aponeurosis:* lastly, upon the same surface of the foot we find the four *dorsal interosseous aponeuroses*, viz. one for each interosseous space.

The Plantar Aponeuroses.

The plantar aponeuroses or fasciæ are three in number,—one *middle*, the other two *lateral*.

The *middle plantar aponeurosis* is very strong, is attached to the inner of the posterior tubercles of the calcaneum, becomes suddenly contracted, and afterwards gradually expands without diminishing perceptibly in thickness. Opposite the anterior extremities of the metatarsal bones, it divides into four

bands, which are themselves bifurcated almost immediately, so as to embrace the flexor tendons of the four outer toes. Becoming moulded on the sides of these tendons, they furnish those of each toe with an almost complete sheath, which is attached to the upper and lateral borders of the anterior glenoid ligament of the corresponding metatarso-phalangal articulation, and becomes continuous with the tendinous sheath of the corresponding toe. These four sheaths are separated by three arched openings, through which proceed the lumbricales and interosseous muscles and the plantar vessels and nerves. There is a perfect analogy between the middle plantar and the middle palmar aponeurosis; but the former is by far the stronger. It constitutes, indeed, a true ligament for the foot, offers a powerful resistance to the forced extension of the phalanges upon the bones of the metatarsus, and supports the antero-posterior arch of the sole of the foot. I have known exceedingly violent pain to be produced by distension, and probably laceration of some of the fibres of this aponeurosis. The margins of the middle plantar aponeurosis are curved upwards, so as to embrace the flexor brevis digitorum on each side; they become continuous with the external and internal plantar aponeuroses, and form septa between the muscles of the middle and those of the external and internal plantar regions: in front these septa are complete, but only partial behind. The upper surface of this fascia gives attachment, posteriorly, to the short flexor of the toes: the proper tendinous expansion of this muscle appears to be given off from the upper surface of the plantar aponeurosis.

Some transverse fibres strengthen this fascia in front, and I shall also notice some other transverse fibres, perfectly distinct from the preceding, which form a true transverse ligament for the four outer toes: it is situated opposite the middle of the lower surface of the first phalanges, and is admirably adapted for opposing their dislocation.

The external and internal plantar aponeuroses. The *external plantar aponeurosis*, very thick behind and thin in front, gives attachment by its upper surface to the abductor muscle of the little toe, and is bifurcated at the posterior extremity of the fifth metatarsal bone. The external division of this bifurcation is very strong, is inserted into the enlarged posterior extremity of the fifth metatarsal bone, and may be regarded as a powerful medium of connection between that bone and the cuboid. The *internal plantar aponeurosis* is thin in comparison with the external; it commences behind by an arch, extending from the inner malleolus to the os calcis; its inner margin is attached to the corresponding border of the tarsus, and is continuous with the dorsal annular ligament and with the dorsal fascia of the foot; its outer margin is blended with the middle plantar fascia, or rather is reflected upwards, to complete the sheath for the internal muscles of the foot.

These three plantar fasciæ just described form three sheaths, which are quite distinct in their anterior five sixths, but communicate with each other behind.

The *internal plantar sheath* includes the abductor and the short flexor* of the great toe, which are separated from each other by a layer of fibrous tissue; it also contains the internal plantar artery and nerves.

The *external plantar sheath* includes the abductor and the flexor of the little toe, which are also separated by a tendinous layer. Lastly, the *middle* plantar sheath includes the short flexor of the toes, the tendon of the flexor longus digitorum, the flexor accessorius, the lumbricales, the tendon of the flexor longus pollicis, the oblique adductor †, the transversus pedis, and the external plantar vessels and nerves. The sheath of the flexor brevis digitorum is completed above by an aponeurotic layer, which separates it from the tendons of the long flexor and from the accessorius. A proper sheath exists for the oblique adductor †, and a subdivision of the same sheath for the transverse

* [*I.e.* The inner half of the flexor brevis pollicis of anatomists generally.]
† [Including the outer portion of the flexor brevis pollicis of most anatomists.]

adductor. It is formed above by the interosseous aponeuroses, and below by a thin layer attached to the circumference of the deep hollow in which the adductors are lodged. Lastly, the *inferior interosseous aponeurosis* is remarkable for its thickness, and for the septa which it gives off between the interosseous muscles.

The sheaths into which the flexor tendons of the toes are received opposite the phalanges, resemble so exactly those of the fingers, that I shall not anticipate what will be said hereafter regarding the latter. We find the same system of synovial membranes, and the same loose, membranous, and extensible cellular tissue for the flexor tendons of the toes, as for those of the fingers. In all sheaths that are partly osseous and partly tendinous, we find a synovial membrane *; but, on the other hand, there is nothing more than a loose cellular tissue in situations where a tendon or muscle glides in the interior of a confining aponeurosis.

The Aponeuroses of the Upper Extremity.

These comprise the aponeuroses of the shoulder; the brachial aponeurosis; the aponeurosis of the fore-arm; the dorsal and anterior annular ligaments of the carpus; the palmar aponeurosis; and, lastly, the sheaths for the tendons of the flexor muscles of the fingers.

The Aponeuroses of the Shoulder.

These are the *supra-spinous*, the *infra-spinous*, the *sub-scapular*, and the *deltoid aponeuroses*.

The *supra-spinous aponeurosis* is a thick layer of fibrous tissue, attached to the entire circumference of the supra-spinous fossa, and converting it into a sort of osteo-fibrous case, that serves as a sheath for the supra-spinatus muscle, to which it also affords several points of attachment. This tendinous layer is gradually lost, externally, under the acromio-coracoid arch.

The *infra-spinous* aponeurosis is an equally dense and strong fibrous lamina, attached to the entire margin of the infra-spinous fossa, and completing the osteo-fibrous sheath of the infra-spinatus muscle: it is continuous on the outside with the brachial fascia, and gives off from its anterior surface a thick septum intervening between the scapular attachments of the teres major and those of the teres minor, and also some thinner septa interposed between the teres minor and the infra-spinatus, and between the different portions of the infra-spinatus muscle itself.

The *deltoid aponeurosis.* The infra-spinous aponeurosis having reached the posterior border of the deltoid muscle, splits into two layers: of these, the superficial layer invests the deltoid, and terminates in the brachial aponeurosis; the deep layer continues to cover the tendon of the infra-spinatus, and becomes attached to the tendon of the short head of the biceps. Some very loose cellular tissue, or even a synovial bursa, separates this aponeurosis from the head of the humerus, and the tendons inserted around it.

The *sub-scapular aponeurosis* is a very thin membrane, which completes the sheath of the sub-scapularis, and gives the muscle some points of attachment It is fixed to the entire margin of the sub-scapular fossa.

The Brachial Aponeurosis.

The *brachial aponeurosis* commences above at the clavicle, the acromion, and the spine of the scapula, and is continuous with the infra-spinous aponeurosis: on the inner side it arises from the tendons of the pectoralis major and the latissimus dorsi; and, in the interval between them, from the cellular tissue of the axilla: it envelops the arm as far down as the elbow, where it becomes continuous with the fascia of the fore-arm, and is attached to the different bony projections presented by the surface of that joint. Its *superficial surface* is separ-

* See note on Aponeurology, p. 389.

ated from the skin by vessels and nerves, to which it furnishes sheaths of greater or less extent. We may admit the existence of a superficial fascia between the vessels and the skin.

Its *deep surface* presents various septa dividing its interior into a certain number of thin sheaths for the several muscles. It is composed almost entirely of circular fibres, some of which have a somewhat spiral direction: these fibres are intersected at right angles by others passing vertically downwards to the fascia of the fore-arm.

The brachial aponeurosis is so loose as to permit the free exercise of the muscles contained within it, yet sufficiently tense to prevent their displacement.

It is slightly thickened on either side, along the outer and inner borders of the humerus, and gives off in those situations two very strong intermuscular septa,—one external, the other internal. These septa are in every respect analogous to those of the femoral fascia, and divide the brachial sheath into two great compartments,—*an anterior*, containing the muscles on the anterior aspect of the arm, viz. the biceps, the brachialis anticus, and the coraco-brachialis, also the upper or brachial portion of the supinator longus, and the extensor carpi radialis longior; the *posterior* compartment belongs to the triceps.

The *external intermuscular septum* arises from the anterior border of the bicipital groove, by a narrow and very thick extremity, blended with the posterior margin of the tendon of the deltoid: it reaches the outer border of the humerus, expands and becomes somewhat thinner, and separates the anterior from the posterior muscles, more especially the triceps from the brachialis anticus, affording atttachments to them both. It is perforated very obliquely by the musculo-spiral or radial nerve, and the superior profunda artery, which at first lie behind, but are afterwards in front of it. The sheath of this nerve and artery establish a free communication between the anterior and posterior compartments already alluded to.

The *internal intermuscular septum*, broader and thicker than the preceding, but like it of a triangular form, arises from the posterior border of the bicipital groove, below the teres major, is continuous with the tendon of the coraco-brachialis, crossing it at a very acute angle, and becoming partially united to and blended with it, proceeds along and adheres closely to the inner border of the humerus, and terminates at the inner condyle or epitrochlea of that bone. Both of these septa are formed by bands and fibres given off in succession from the corresponding borders of the humerus, and they both afford attachments to the brachialis anticus in front, and to the triceps behind. The ulnar nerve is anterior to the internal septum in the upper part of the arm, but perforates it, and remains in contact with its posterior surface, passing between the attachments of the triceps.

From these two great sheaths the proper sheaths of the muscles proceed. First, the deltoid has its proper sheath: another thin aponeurotic layer, gradually becoming thicker from above downwards, consisting almost entirely of vertical fibres, and forming one of the origins of the aponeurosis of the fore-arm, separates the biceps from the brachialis anticus: again, the brachial vessels and the median nerve have a special sheath, which also receives at its upper part the basilic vein, and the ulnar and internal cutaneous nerves; this is the *brachial canal*, the counterpart of the femoral canal; it establishes a communication between the cellular tissue of the axilla, and that in the bend of the elbow: lastly, a tendinous layer separates the upper half of the long head of the triceps from the other portions of that muscle: the sheath of the coraco-brachialis is given off from the inner edge of the biceps.

We must consider as dependences of the common brachial investment, the several sheaths furnished by it to the cephalic, basilic, and median veins, to the branches of the internal cutaneous nerve, and to the superficial ramifications of the musculo-cutaneous nerve. When an artery or a vein previously situated under an aponeurosis becomes subcutaneous, the perforation in the aponeurosis is almost always of an arched form.

The brachial aponeurosis has no muscle analogous to the tensor vaginæ

femoris; the pectoralis major, and the latissimus dorsi, are sufficient to effect its tension.

The Aponeurosis of the Fore-arm and Hand.

The Aponeurosis of the Fore-arm.

Dissection. Make a circular incision through the skin, immediately above the elbow, and from this let two vertical incisions be carried downwards to the wrist, one in front and the other behind; let the incisions extend through to the fascia without dividing it: then cautiously remove the skin, being careful to take with it the subcutaneous adipose tissue; the superficial veins and nerves may be preserved. The external surface of the fascia may be studied first, and its several sheaths afterwards opened in succession.

The aponeurosis or *fascia of the fore-arm* forms a general sheath, entirely surrounding or embracing that portion of the upper extremity, with the exception of the posterior border of the ulna. It is semi-transparent, and hence can be seen to be traversed by white lines, generally vertical in their direction, which indicate a corresponding number of thickenings of the sheath, and intermuscular septa given off from them.

It is separated from the skin by the superficial veins and nerves; by its upper part it gives numerous attachments to the subjacent muscles, and this renders the dissection very difficult. By making a vertical incision, however, along the separate sheath which it furnishes to each of the muscles, and then carefully removing the latter, a good idea may be formed of the numerous angular compartments into which the common cavity of the fascia is subdivided. In the first place, it will be seen that this fascia, like all other investing aponeuroses, is composed of proper and superadded fibres; that the proper fibres are nearly or quite circular, are more or less oblique, and more or less interlaced, but the superadded fibres are vertical. It will be found that it is twice as thick upon the dorsal as upon the palmar surface of the fore-arm; that its thickness and its strength increase from above downwards; and that it is strengthened by a great number of superadded fasciculi, consisting of aponeurotic expansions from the tendons of the adjacent muscles. Thus the brachialis anticus on the outside, the biceps on the inside and in front, and the triceps behind, give off tendinous expansions to this aponeurosis: of these the most remarkable is, without doubt, that given off from the biceps, which muscle may be regarded, indeed, as the tensor of the anterior portion of the fascia. This expansion constitutes, in fact, one of the terminations of the biceps, with the external fasciculi of which it is continuous, and moreover arises from the outer edge and the anterior surface of its tendon. This expansion, so important in consequence of its relations with the brachial artery, passes obliquely inwards and downwards, and, as it expands, intersects at right angles the vertical fasciculi proceeding from the epitrochlea and epicondyle of the humerus. These last mentioned fasciculi also appear to me to be supplementary; they are continuous with the common tendons of origin of the external and internal muscles of the fore-arm, and constitute the anterior walls of those two multilocular pyramids, of which one is on the inner, the other on the outer side of the fore-arm, or of that series of trumpet-shaped cavities (*cornets*), as M. Gerdy calls them, from each of which the muscles of these regions take their origin. I must not omit to mention the thick tendinous band, which arises from the entire length of the posterior border of the ulna, divides into two layers to give origin to the flexor carpi ulnaris, and by its internal or deep surface affords attachment to the flexor sublimis.

In the fascia of the fore-arm there are numerous foramina for the passage of vessels and nerves, but I shall direct attention to one very large orifice existing in front, at the bend of the elbow, and bounded on the inside by the outer margin of the tendinous expansion of the biceps. This opening establishes a free communication between the subcutaneous and the sub-aponeu-

rotic cellular tissue at the bend of the elbow, and leads into a sort of fossa, in which are found the tendon of the biceps, the brachial artery, the commencement of the radial artery, and the median nerve. This fossa is lined by aponeurotic laminæ; on the *outside* by the layer which covers the inner surface of the supinator longus, the radial extensors, and the flexor sublimis; on the *inside* by the layer which completes the sheath of the pronator teres: it communicates above with the canal of the brachial artery, and below with the canals through which the radial, ulnar, and interosseous arteries and the median nerve proceed downwards to the fore-arm.

From the internal surface of this fascia a number of laminæ are given off, to form the following muscular sheaths:—

In the *anterior region of the fore-arm* a transverse septum, thicker below than above, divides the superficial layer of muscles from the middle layer, consisting of the flexor sublimis, and also from the deep layer, composed of the flexor profundus digitorum and the flexor longus pollicis. Other septa, passing from before backwards, divide the muscles of the superficial layer from each other. Lower down the sheaths of the flexor carpi radialis and palmaris longus, which are perfectly distinct from each other, are situated in front of the remainder of the fascia; and this has led to the statement of some anatomists, that the fascia is perforated by the tendons of these muscles, especially by that of the palmaris longus. The radial artery has a special sheath throughout its whole extent, the ulnar artery and nerve have a proper sheath only in the lower part of the fore-arm.

In the *posterior region of the fore-arm*, the fascia is much stronger than in the anterior. A transverse layer separates the muscles of the superficial from those of the deep layer; and septa, passing from behind forwards, subdivide these common sheaths into several smaller ones, corresponding in number to that of the muscles. Thus we find a sheath for the extensor communis digitorum, a second for the extensor digiti minimi, a third for the extensor carpi ulnaris, and a fourth for the anconeus. The supinator longus and the two radial extensors of the wrist appear to be in the same sheath: but a more or less distinct membrane surrounds the first of these muscles: the supinator brevis has also a proper sheath. We find a common sheath for the extensor longus pollicis and the extensor proprius indicis. The abductor longus and the extensor brevis pollicis, which, properly speaking, constitute but one muscle, have also a common sheath accompanying them as far as the dorsal annular ligament of the wrist.

The Dorsal Annular Ligament of the Wrist, and the Dorsal Aponeurosis of the Metacarpus.

The *dorsal annular ligament of the wrist* (*r*, *fig.* 121.) may be considered as a dependence of the fascia of the fore-arm, which in this situation is strengthened by a great number of fibres. It is a band of six or eight lines in width, passing obliquely inwards and downwards over the extensor tendons of the hand, perforated by a number of openings for the passage of vessels, and distinguishable from the fascia of the fore-arm only by its somewhat greater thickness and by the parallel arrangement of its fasciculi. It arises internally from the pisiform bone and the palmar fascia, passes first over the ulnar side, and then the posterior surface of the carpus, is interrupted by the outer margin of the groove for the two radial extensor muscles, takes a fresh origin from that margin, covers the radial side of the wrist, and is inserted partly into the radius, and partly into the fascia of the fore-arm. From the anterior surface of this thick fibrous band arise several small prolongations, which are interposed between the numerous tendons passing over the dorsal and radial aspects of the carpus, and convert the grooves upon the lower extremities of the radius and ulna into canals. Thus proceeding from without inwards, and from before backwards, we find, 1. a sheath for the united tendons of the abductor longus

and extensor brevis pollicis; 2. and 3. two distinct sheaths opposite the radius,—one for the two radial extensors of the carpus, the other for the extensor longus pollicis, which sheaths become blended together lower down into a single completely fibrous sheath; 4. a fourth sheath, stronger than the preceding, for the extensor communis digitorum and the extensor proprius indicis; 5. an entirely fibrous sheath for the extensor digiti minimi; 6. a very strong sheath for the extensor carpi ulnaris, which is prolonged below the ulna, and accompanies the tendon as far as the fifth metacarpal bone. All these sheaths are lined by synovial membranes*, which extend some distance above the dorsal annular ligament, and, on the other hand, accompany the tendons very far down, sometimes even to their insertions.

The *dorsal aponeurosis of the metacarpus* is a continuation of the dorsal annular ligament: it is composed of a very thin layer of transverse fibres, and separates the extensor tendons from the subcutaneous vessels and nerves. A very loose, extensible, and elastic cellular tissue takes the place of the synovial membranes over these tendons, and greatly facilitates their movements.

The Anterior Annular Ligament of the Carpus.

The deep groove upon the anterior surface of the carpus is converted into a canal by a very thick fibrous band, viz. the *anterior ligament of the carpus* (*g, fig.* 118.). It commences internally by two well marked origins, separated from each other by the ulnar nerve, one being from the pisiform bone and the tendon of the flexor carpi ulnaris, the other from the unciform bone. The first bundle passes downwards, the second transversely, and their united fibres, some of which are transverse and others interlaced, terminate at the trapezium and the scaphoid, giving off an expansion to the fascia covering the ball of the thumb, with which they are continuous. This ligament is continuous above with the fascia of the fore-arm, which is much thickened in this situation: it receives, in front, the expanded tendon of the palmaris longus, and terminates below in the palmar fascia. Its anterior surface gives attachment to most of the muscles of the thenar and hypothenar eminences. A small portion only of this ligament is generally seen and described, viz. the free portion. If it is wished to obtain a perfect conception of it, the muscles attached to its anterior surface should be carefully removed; it will then be seen, that on the outside it describes a curve having its concavity directed inwards, in order to be attached to the scaphoid and the trapezium, and that the sheath of the flexor carpi radialis is contained in its substance: this sheath is entirely fibrous above, and partly fibrous and partly osseous below, where it converts into a canal the groove on the trapezium.

While there are almost as many synovial membranes as there are sheaths under the dorsal ligaments of the carpus, on the palmar aspect nine tendons with the median nerve form but a single bundle, which is lubricated by one or two synovial membranes. This synovial membrane* presents a curious arrangement, subject moreover to numerous varieties. It lines the posterior surface of the anterior annular ligament of the carpus, is prolonged above and below that ligament, and is reflected (without passing between the different tendons) upon the anterior surface of the bundle formed by them and by the median nerve, which is to their outer side. In order to obtain an accurate idea of the termination of this synovial membrane, cut across the tendons at the lower part of the fore-arm, and turn them forwards upon the palm of the hand: it will then be seen that the synovial membrane is reflected upon the ulnar border of the bundle of tendons, that it lines the posterior surface of this bundle, passing more or less between the tendons, and separating them from each other in a rather irregular manner; that it is reflected upon the groove of the carpus, prolonged upwards and downwards much farther than it was in front, and di-

* See note, p. 389.

vided below into four small prolongations corresponding to the flexor tendons of each finger. Nor is this all, for there is a special synovial membrane for the flexor longus pollicis. In order to expose this, the synovial membrane must be cut through where it is reflected, on its radial side, from the annular ligament on to the median nerve and the anterior surface of the bundle of tendons: a special and very extensive synovial membrane will then be seen to pass high up along the tendon of the flexor longus pollicis, and to be prolonged downwards as far as the last phalanx of the thumb.

The Palmar Aponeurosis.

The *palmar fascia* (*c*, *fig.* 118.) forms a common sheath for all the muscles of the palm of the hand, and is divided into three portions,—a *middle* and two *lateral*.

The *middle portion*. This is the only part generally described as the palmar fascia; it is triangular and strong, but of variable thickness: it binds down the numerous subjacent tendons. It arises from the anterior surface and lower margin of the anterior annular ligament of the carpus, and from the tendon of the palmaris longus, which may be regarded as its tensor muscle. Between these two origins the ulnar artery penetrates into the palm of the hand. Not unfrequently the expanded tendon of the palmaris longus forms a fibrous layer in front of the proper palmar fascia. This fascia is narrow and thick at its origin, but expands as it proceeds from above downwards, and, opposite the heads of the metacarpal bones, divides into eight prolongations for the four inner fingers. At the seat of this division we find very strong transverse fibres binding the prolongations together, and preventing disjunction of the fingers, and laceration of the fascia. By this arrangement four arches are formed, under which the tendons of the flexor muscles pass: between these four arches there are three smaller ones, giving passage to the collateral vessels and nerves of the fingers, and to the lumbricales, so that altogether there are seven arches. These arches are true fibrous canals. In order perfectly to understand their structure, make a vertical incision through the palmar fascia; it will then be seen, that, opposite the arches, tendinous prolongations or tongues are detached from the deep surface of the fascia: these prolongations turn round the sides of the tendons so as to embrace them, and become continuous with the anterior or glenoid ligament of the metacarpo-phalangal articulations: the same arrangement obtains with regard to the three small arches for the vessels and nerves situated between the four principal tendinous arches. The palmar fascia is, moreover, intimately united to the skin by very numerous prolongations: its deep surface covers the superficial palmar arch of the arteries of the hand, the median and ulnar nerves, and the flexor tendons; a very loose and extensible cellular tissue separates it from these parts, and facilitates the movements of the tendons. From its inner margin is given off a very strong layer, which becomes continuous with the interosseous aponeurosis, and separates the middle from the internal palmar region; a thinner layer proceeds from its outer margin, and passes down between the muscles of the thenar eminence and the first lumbricalis muscle. This small muscle, called the *palmaris brevis* (*b*, *fig.* 118.), arises from the inner margin of the middle palmar fascia, and is merely a cutaneous muscle.

The *external and internal palmar fasciæ*, or the *thenar and hypothenar aponeuroses*. These consist of two rather thin fibrous layers, forming the sheaths of the muscles of the ball of the thumb and those of the little finger: they are both continuous with the middle palmar fascia: the external appears to consist, in a great measure, of an expansion from the tendon of the abductor longus pollicis; and the internal, of an expansion from that of the flexor carpi ulnaris. At the limits between these aponeuroses and the middle fascia are formed two septa, passing from before backwards, and dividing the palm of the hand into three distinct sheaths,—one median, completed by the interosseous aponeurosis.

and intended for all the flexor tendons and the principal vessels and nerves of the hand; the other two placed on either side, and binding down the muscles of the thenar and hypothenar eminences.

The Sheaths of the Flexor Tendons of the Fingers, and their Synovial Membranes.

After leaving the arches, or rather the curious sheaths, formed by the palmar fascia immediately above the corresponding metacarpo-phalangal articulation, each pair of flexor tendons is received into a special sheath, by which they are accompanied down to the last phalanx. It will be remembered that the anterior surfaces of the first and second phalanges are marked by a longitudinal groove; to the two borders of this groove is attached a very regular semi-canal of fibrous tissue, which is exactly large enough to contain the two flexor tendons. This very strong sheath preserves its shape when the tendons have been removed; and a correct idea of its importance may be obtained, by observing the effects of contraction of the flexor muscles after it has been divided. This sheath is formed of parallel semicircular laminæ, placed one above the other, densely aggregated over the bodies of the phalanges, and for the most part forming a continuous sheath, but becoming more and more separated, and sometimes even completely disappearing opposite the articulations and the articulating extremities of the bones. It appears to me, that, in the movements of flexion, these articular rings are pushed into each other. The sheath ceases altogether above the articulation of the second with the terminal phalanx.

A very remarkable synovial membrane *, which is prolonged upwards beyond the arches formed by the palmar fascia, lines the whole length of each osteo-fibrous sheath *on the one hand*, and *on the other* is reflected upon the two flexor tendons, affording each of them a sheath, and forms two, often three or four triangular folds, having their bases directed upwards, and being perfectly analogous to the so-called adipose ligament of the knee joint. Of these folds, the superior is situated opposite the upper extremity of the first phalanx, and extends from the tendon of the flexor sublimis to that of the flexor profundus; the inferior fold passes from the bifurcation of the superficial tendon to the deep tendon; the others are intermediate, and proceed from the phalanx to the two tendons. These synovial folds can be very well seen, by raising and separating the flexor tendons from the phalanges. Not unfrequently the synovial membrane forms a hernia between two of these tendinous rings, either opposite the body of a phalanx, or still more commonly over one of the articulations. We may add, that these synovial folds are probably intended to support the nutritious vessels of the tendons, and not to connect these tendons together.

* See note, p. 389.

SPLANCHNOLOGY.

General observations on the viscera.—External conformation.—Structure.—Developement.—Functions.—Dissection.

Splanchnology, (from σπλάγχνον, *viscus*) is that division of anatomy which treats of organs more or less compound in their structure. Some of these are contained within the three great visceral cavities (*the viscera*), whilst others are situated without these cavities (*organs*, properly so called).*

The brain, the spinal cord, the heart, and the organs of the senses, are generally included in this division. I have thought it advisable, however, to confine myself here to the description of the digestive, respiratory, and genito-urinary apparatus. The organs of the senses, the brain, and the spinal cord, will be studied more advantageously in connection with the rest of the nervous system, and the heart with the other organs of the circulation.

As the organs we are about to examine have few relations with each other, they do not admit of such extended and important general remarks as those which preceded the osteological and myological divisions. I shall content myself with explaining briefly the method in which the description of each organ should be pursued.

Every organ presents for consideration its external conformation, its internal conformation or its structure, its developement, and its functions.

The External Conformation of Organs.

The description of the external conformation of organs includes that of their nomenclature, number, situation, direction, size, shape, and relations.

Nomenclature. The nomenclature of organs has not been subjected to so many changes as that of the bones and muscles; the names adopted by the oldest authors have been retained in modern science, and are even used in common language.

The names of organs are derived, 1. from their uses, as the *œsophagus* (from οἴω, I convey, and φάγω, I eat); also, the *lachrymal* and the *salivary* glands: 2. from their length, as the *duodenum:* 3. from their direction, as the *rectum:* 4. from their shape, as the *amygdalæ* (the tonsils): 5. from their structure, as the *ovaries:* 6. from the name of the authors who have best described them, as the *Schneiderian membrane*, the *Fallopian tubes:* lastly, they are conventional words, for example, the *tongue*, the *liver*, &c.

Number. Some organs are single; others exist in pairs. Varieties in number are very common, both by excess and by defect. Thus three kidneys have been found in the same individual, and there is often only one. Examples have been recorded of individuals having three testicles; one is uncommon. Lastly, varieties by excess almost always result from the division, and those by defect from the union or fusion, of organs.

Situation. This must be considered with regard to the region of the body occupied by an organ, *i. e.* its *general* or *absolute situation;* and also with regard to its relations with neighbouring organs, *i. e.* its *relative situation.* Thus, when it is stated that the stomach occupies the left hypochondrium and the epigastrium, its absolute or general situation is indicated; but when it is added that this viscus is situated between the œsophagus and duodenum, below the diaphragm, and above the transverse mesocolon, its relative situation is implied.

Many of the organs are subject to varieties of position; and this constitutes

* All the viscera are organs, but all the organs are not viscera. The word viscus is probably derived from *vescor*, I eat, because a great number of the viscera are engaged in the functions of nutrition.

an important point in their history. These varieties of position depend upon congenital or upon accidental displacement, either affecting the particular organ only, or consequent upon displacement of the neighbouring organs; or they may result from a change in the size of the organ itself.

Size. The *absolute* size of an organ is determined by linear measurements, by the quantity of water which it displaces, and by its weight; *its relative size*, by comparison with bodies of a known size, or with other organs.

The size of organs is subject to a great number of varieties. These depend either on age, as in the *liver*, *testicles*, and *thymus gland*; on sex, temperament, or on individual peculiarities; also on the state in which an organ is found,—for example the *uterus*, *penis*, and *spleen*. Lastly, there are some pathological variations, which should not be omitted in a treatise upon descriptive anatomy.

Figure. The figure of the organs treated of in splanchnology appears to follow these rules. The double organs do not exactly resemble each other on the right and left sides of the body. The single organs, occupying the median line, are symmetrical; but most of those which are removed from that line are not symmetrical. Nevertheless, symmetry is not so completely wanting in the viscera belonging to nutritive life, as stated by Bichat, for the *stomach* and the *small* and *great intestines* may be divided into two equal halves.

In regard to their forms, organs are compared in general either with familiar objects, or with geometric figures. Thus a *kidney* is said to resemble a kidney-bean, and either *lung*, a cone. In very irregular organs, we merely describe the surfaces and the borders. We shall not find in the viscera the same constancy of form as exists in the organs of relation.

Direction. The direction of an organ is determined in the same manner as that of the bones and muscles, viz. by its relations with the imaginary planes surrounding the body, or with the mesial plane.

Relations. The figure of an organ being determined, its surface is then divided into *regions*, the relations of which are accurately ascertained. These regions are generally termed *surfaces* and *borders*. As the situation of many organs is subject to great varieties, their relations must also vary. Too much cannot be said of the value of an accurate knowledge of these relations, from which a number of the most important practical inferences may be derived.

The Internal Conformation or Structure of Organs.

The surface of an organ being well understood, we next proceed to the study of its structure, comprising its colour, its consistence, and its anatomical elements.

Colour. The colour both of the surface and the substance of an organ require to be studied. All variations of colour should be very carefully noted. Age and disease have much influence over it; and it is often difficult to distinguish positively between its physiological and pathological condition.

Consistence. The *consistence*, *density*, and *fragility* of organs are connected with their structure. The specific gravity or density of a single organ only, the *lung*, has been accurately studied, and that in a medico-legal point of view. In estimating the consistence and fragility of organs we can only approximate the truth. It is desirable that some more methodical and accurate means should be devised for the estimation of these qualities.

Anatomical elements. The determination of the immediate anatomical elements, or tissues, which enter into the composition of an organ, together with their proportions and their arrangement, constitutes the knowledge of its structure. Every organ has either a cellular, fibrous, cartilaginous, or bony framework. Some organs are provided with muscular fibres, or even with distinct muscles; they all contain the several kinds of vessels, viz. arteries, veins, and lymphatics; and they all possess nerves. The glandular organs have excretory ducts.

In explaining the structure of organs, we shall generally confine ourselves

to a brief enumeration of their constituent parts, referring to works on the anatomy of textures for details which would be misplaced in an elementary treatise.

The Developement of Organs.

The study of the developement of organs, and the changes which they undergo at the different periods of intra- and extra-uterine life, is of the greatest interest, at least as regards some among them. The formation of the soft parts, however, is not nearly so well understood as that of the hard tissues, because the most important phenomena of developement occur during the first weeks after conception. The remarks upon this subject will therefore generally point out some hiatus to be filled up.

The Functions of Organs.

The functions or uses of organs flow so naturally from their anatomical description, that we shall follow the example of the greater number of anatomists, in adding to such description, a short account of the functions of an organ. We shall only notice particularly those uses of organs which depend immediately upon their structure, referring to physiological works for the details and discussions of yet disputed points in the science of functions. No part of anatomy excites so much curiosity and interest as splanchnology, in consequence of the importance of the organs of which it treats. Without a knowledge of this department of anatomy, it is impossible to understand the mechanism of functions the most indispensable to life; and as the organs themselves are the seat of the greater part of the lesions which are assigned to the physician, as well as of many of those which fall under the care of the surgeon, most of the fundamental questions of the healing art require a profound knowledge of these organs.

The Dissection of the Viscera.

The dissection of organs does not consist in merely isolating them from surrounding parts, which, as far as regards those contained in the visceral cavities, is done by simply laying open the latter, but in the separation of their anatomical elements or tissues. For this purpose injections of the most delicate kind, maceration, boiling, preservation in alcohol, desiccation, the action of acids, in short, all the resources of his art, are employed by the anatomist.

Having made these preliminary observations, we shall now describe in succession the organs of digestion, the organs of respiration, and the genito-urinary apparatus.

THE ORGANS OF DIGESTION AND THEIR APPENDAGES.

ALIMENTARY OR DIGESTIVE CANAL.

General observations. — Division. — Mouth and its appendages. —Lips. —Cheeks. Hard and soft palate. — Tonsils.— Tongue. — Salivary glands. —Buccal mucous membrane — Pharynx. — Œsophagus. — Stomach. —Small intestine. —Large intestine. — Muscles of the perineum—Developement of the intestinal canal.

THE organs of digestion form a long canal, the *alimentary* or *digestive canal*, extending from the mouth to the anus, which receives alimentary substances, induces in them a series of changes, by which they are rendered fit to repair the losses incurred by the body, and moreover presents a vast absorbent surface for the action of the lacteal vessels. The entire series of these organs constitutes the *digestive apparatus.*

The existence of an alimentary canal is one of the essential characters of an

animal. In consequence of possessing it, animals may be detached from the soil, so as to move from place to place. In the lowest species, the entire animal is nothing more than an alimentary sac, having a single opening, and formed by a reflection of the skin; so that, according to the beautiful observation of Trembley, when polypes are turned inside out, the digestive process is performed as well by their external as by their internal surface. Ascending in the scale of animals, the canal soon presents two openings, acquires larger dimensions, becomes more or less convoluted, and is distinct from other systems of organs. A skeleton clothed by muscles is interposed between it and the skin. It becomes more and more voluminous, in proportion as the nutritive materials and the textures of the body differ more widely in their chemical composition. What a difference there is, in this respect, between certain fishes, in which the alimentary canal is not nearly so long as the animal, and some herbivora; the ram for example, in which it is twenty-seven times the length of the body. Carnivorous animals, again, have a short and narrow alimentary canal. Man being destined to live, both upon animal and vegetable substances, occupies, as it were, a middle station between the herbivora and carnivora.

General situation. The digestive canal is situated in front of the vertebral column, with the direction of which the straight portion of the canal accurately corresponds, whilst its tortuous part is distant from, though invariably connected with it by means of membranous attachments. It commences at the lower part of the face, traverses the neck and the thorax, penetrates into the abdominal cavity, which is almost exclusively intended for it, and the dimensions and mechanism of which bear strict relation to the functions of the alimentary canal; and it terminates at the outlet of the pelvis, anterior to the coccyx, by the anal orifice. Its upper part is in immediate relation with the organs of respiration; its lower, with the genito-urinary apparatus.

Dimensions. The length of the digestive canal has been calculated to be seven or eight times that of the body of the individual. Its diameter is not equal through its whole extent; and its alternate expansions and contractions establish very distinct limits between its several portions. The largest portion is undoubtedly that which receives the name of the stomach; the narrowest parts are the cervical portion of the œsophagus, the pyloric opening of the stomach, and the ileo-cæcal orifice. It is important to remark, that the transverse dimensions of an alimentary canal have to a certain extent an inverse ratio, to its length. Thus a very wide intestinal canal is generally less remarkable for length. This remark is illustrated by comparative anatomy in the fact, that in the horse, an herbivorous animal, the intestinal canal is shorter, but at the same time of a much greater caliber than in the ruminantia, which are also herbivorous.

Direction. The upper or supra-diaphragmatic portion of the alimentary canal, through which the food merely passes, is straight; the sub-diaphragmatic portion is very much convoluted upon itself, but again becomes straight before its termination.

General form. The digestive apparatus forms a cylindrical continuous canal, in which we have to consider an external and generally free serous surface, and an internal mucous surface.

Structure. The digestive canal is composed of four membranes or tunics:— 1. The most external is the *serous* or *peritoneal coat*, also named the *common tunic*, because it is common to almost all the organs in the abdominal cavity. This membrane, which may be regarded as an accessory tunic, is often incomplete, and even entirely wanting throughout the supra-diaphragmatic portion of the digestive canal. At the same time that it constitutes the external covering of this canal, it separates it from the neighbouring parts, facilitates its movements, and forms certain bands, which maintain the several portions of the canal more or less fixedly in their proper situations. The serous membranes of which this external tunic is only a dependence, are shut sacs, which, on the one hand, line the walls of the cavities to which they belong,

and, on the other, are reflected upon the organs contained therein *, without, however, including them within their own proper cavity.

A serous membrane may be compared to a balloon, or rather to a double night-cap; its internal surface is free, smooth, always moistened with serosity, and its parietal and visceral portions are in contact with each other: its external surface is adherent.†

2. Beneath the serous coat is situated the *muscular coat*, consisting of two layers,—one superficial, composed of longitudinal fibres; the other deep and composed of circular fibres.

These fibres are colourless, like almost all the muscles of nutritive or organic life.‡

3. The *fibrous coat*, interposed between the muscular and mucous coats, may be regarded as constituting the framework of the alimentary canal. It consists of dense areolar cellular tissue.§

4. The *mucous coat* or *membrane* forms the internal lining of the digestive canal. Every cavity having a communication with the exterior is lined by a mucous membrane, so called on account of the mucus with which it is constantly lubricated.

In mucous membranes generally, we find, 1. a *dermis* or *chorion*. 2. *Papillæ* or *villosities*, which give them a velvety appearance; hence the designation *papillary*, *villous*, or *velvety* membrane frequently given to them. 3. On the outer surface of the dermis we find a very dense *network of capillary* vessels, which may be completely injected from the veins, but less easily and less completely from the arteries. 4. Either follicles or small closed sacs are seen here and there in the substance of mucous membranes; but they are not essential, as the name *follicular*, given to these membranes by Chaussier and some other anatomists, would seem to indicate.

All mucous membranes are covered by an extremely delicate pellicle, which may be readily detected by means of a simple lens. Injections made by the arteries and veins never penetrate it, nor is it reddened by inflammation. I

* [Hence the terms parietal and visceral, applied to these two portions of a serous membrane (see *fig.* of the testis, letters *p* and *v*).

In consequence of the existence of an aperture in the free extremity of each Fallopian tube, the peritoneal cavity in the female is an exception to the general rule, that serous membranes form shut sacs, not communicating with the external medium.]

† [Serous membranes are transparent, colourless, extremely thin, and highly distensible and elastic. They are composed of a basis of cellular tissue, loose and connected to the adjacent tissues externally, more or less condensed towards the inner and free surface of the membrane, and covered with an extra-vascular epithelium, consisting of a single layer of nucleated cells, flattened into the form of scales, and arranged parallel to that surface. Cilia have been detected on many serous membranes, as on the peritoneum and pericardium of the frog; on the same parts, and also on the pleura and lining membrane of the ventricles of the brain in certain mammalia; and in the latter situation in man. Bloodvessels ramify in the subserous cellular tissue, but do not penetrate far towards the free surface, where they are entirely wanting. Lymphatics also exist in the subserous tissues, but have not been found in the membranes themselves; nor have nerves been traced into them. The fluid secretion found in serous cavities appears to be of an albuminous nature.]

‡ [The involuntary muscular fibres of the alimentary canal (according to Dr. W. Baly) consist of bands, varying from $\frac{1}{2500}$th to $\frac{1}{3800}$th of an inch in diameter, apparently formed of flattened tubes, in the parietes of which are seen, at irregular intervals, numerous transparent oval or linear bodies, sometimes very difficult of detection: they are believed to be the nuclei of the primitive cells, from which the fibre itself is developed. These fibres contain no varicose filaments, nor do they present any transverse striæ, like those of animal life (see p. 249.). Moreover, although they have a parallel arrangement in the fasciculi into which they are collected, the fasciculi themselves are irregularly interlaced, at the same time that they all pursue a common direction.

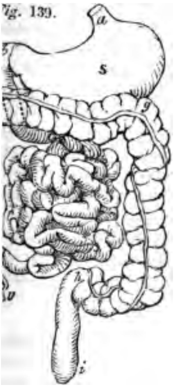
The muscular coat of nearly the entire alimentary canal consists essentially of these involuntary or organic muscular fibres; but at the commencement and termination of the canal, where the muscular systems of animal and organic life come into relation with each other, this tunic appears also to consist of fibres resembling those of the voluntary muscles. Thus at the upper part of the œsophagus, fibres containing varicose filaments, and possessing the cross striæ, were detected by Schwann; and it has been shown by Valentin and Ficinus, that these exist all along the œsophagus, and that indistinctly striated fibres are found even at the cardiac end of the stomachs of many mammalia, and of man. Similar fibres were observed by Ficinus in the rectum, near the sphincter ani.]

§ [It is frequently called the *cellular* coat; and, from its white appearance, has been termed (like all other white textures) the *nervous* tunic.]

ıccidentally injected it, however, by means of a tube containing mercury, for injecting the lymphatics by pricking the mucous membrane in dif- places as superficially as possible. The vascular network, thus injected, eedingly delicate; the small globules of mercury traversing it on all di- ns, so as to form rapidly a silvery areolar layer. I have seen this in the ıs membrane of the nose; on the conjunctiva, both over the sclerotic ver the cornea; on the mucous membrane of the vagina, of the tongue, the cheeks. It is very remarkable that the mercury never passes from etwork either into the veins or the arteries; and, moreover, that if the ierces a little too deeply, the veins are injected, but not the epidermic capil- etwork. It is evident, therefore, that this network has no communica- ither with the arteries or the veins. It probably belongs to the lymph- ystem, although I have never observed the lymphatic vessels filled from

sels and nerves. Vessels and nerves also enter into the formation of the alimentary canal: for example, we find a very abundant supply of branches from the adjacent arterial trunks; an immense number of veins, of which those from the sub-diaphragmatic portion of the canal terminate in the vena portæ; absorbent vessels, divided into lymphatics and lacteals; and lastly nerves, almost all of which proceed from the ganglionic system, excepting the pneumogastric and glosso-pharyngeal nerves.

ʼig. 139.



Division of the digestive canal. The digestive canal has been divided into several parts, from differences both in their anatomical characters and their functions. One principal division, which deserves to be retained, is into a *supra-diaphragmatic* and a *sub-diaphragmatic portion.* The *supra-diaphragmatic portion* comprehends the *mouth,* the *pharynx,* and the *œsophagus.* The *infra-diaphragmatic* portion includes the *stomach* (*a b*, *fig.* 139.); the *small intestine,* subdivided into the *duodenum* (*b c*), and the *jejunum* and *ileum* (*c d*); and the intestine, somewhat arbitrarily divided into the *cæcum* (*d e*), the *colon* and the *rectum* (*h i*). The appendages of the digestive canal consist *salivary glands,* connected with the mouth; of the *liver* and the *pancreas,* ted with the duodenum; and of the *spleen,* which may be regarded as endage cf the liver.

ıe lining membrane of the digestive apparatus, forming part of the gastro-pulmonary of the mucous membranes, extends not only throughout the entire alimentary canal, but ıg the ducts of the various glands which pour their secretions into it.

ure in general. Mucous membranes are usually soft, pulpy, incapable of great distension, cerated, somewhat opaque, and, when free from blood, of a pale greyish or ashy hue. mis or chorion (analogous to that of the skin) is a basis of cellular tissue, of very thickness; its attached surface is connected to the subjacent textures, either immove- in the nasal cavities and on the tongue, or loosely, as in the gullet and stomach. The or epithelium with which its surface is always covered (corresponding to the epidermis skin), also varies much in thickness in different situations; it consists of transparent d cells, according to the form and arrangement of which it receives its name. Thus in *mous* epithelium there are generally (as in the mouth and gullet) several layers of f these the deepest are vesicular, and contain a comparatively large nucleus; those on ace are flattened out into polygonal *scales,* from the centre of which the nucleus has isappeared, whilst the intermediate cells present intermediate transitional forms. The d cells of the *columnar* epithelium (found, for example, in the stomach and intes- e developed into oblong cylinders, arranged in a single series, like basaltic columns, icularly to the surface of the dermis. In some situations, as in the nasal cavities and ges, cilia are attached to the free extremities of the cylinders of the columnar epithe- t no cilia have been detected in any part of the *alimentary canal* of man, or the warm- animals: the superficial cells of the epithelium of mucous membranes are continually rown off by a process of desquamation. The different mucous membranes differ in

The Mouth and its Appendages.

The *mouth** is a cavity situated at the entrance of the digestive passages. It occupies the lower part of the face, and is situated between the two jaws below the nasal fossæ, between the cheeks, behind the lips, and in front of the pharynx. It constitutes a very complicated apparatus, in which are performed the several acts of mastication, tasting, and insalivation, the commencement of the act of deglutition, and the articulation of sounds.

Fig. 140.

The dimensions of the buccal cavity are greater than those of the succeeding portion of the alimentary canal; hence bodies may be introduced into it which are too large to pass through the constricted parts of that canal.† The size of the mouth presents every intermediate degree between complete closure with the jaws in contact, and leaving no interval between them, and extreme expansion, when the buccal cavity represents a quadrangular pyramid, the base of which is directed forwards, and the apex backwards. An increase in the capacity of the mouth may also be effected in the transverse direction by the distension of the cheeks, and in the antero-posterior direction by a projection of the lips forwards.

In studying the relative proportions of the several diameters of the buccal cavity, it is found that none of them predominates in man, while in the lower animals the antero-posterior is by far the longest: this depends partly on the great size of their nasal cavities, and partly on the length of their jaws. In connection with this subject, we may remark that in the animal series there is an inverse ratio between the size of the cavity of the cranium and that of the gustatory and olfactory cavities.

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vascularity; the network of capillary vessels in the dermis becomes closer or denser near its surface; the lymphatic vessels also form a network in the same situation; but the epithelium, though organised, is, as stated in the text, perfectly extra-vascular.

Mucous membranes are also more or less abundantly supplied with nerves.

When boiled they yield no gelatine, or rather only as much as would proceed from the cellular tissue and vessels they contain. The fluid secreted by them, or mucus, is viscid, transparent, and colourless, miscible with, but not soluble in water, and not coagulated by heat. It contains, besides the desquamated epithelium scales, proper granular globules, $\frac{1}{1500}$ inch in diameter, and having a very close resemblance to the globules of pus. According to Berzelius, mucus consists of water, a few salts, albumen, and a peculiar animal substance, which he calls mucous matter. This latter, when dried, swells on being placed in water, but, like fresh mucus, is insoluble in that fluid, either hot or cold; it is slightly soluble in dilute acetic and nitric acids, and in caustic alkalies.

The peculiarities presented by particular portions of the mucous membranes, and the structure of the papillæ, villi, follicles, &c. found in some parts of them, will be separately noticed, as opportunity offers.]

* The meaning of the word *mouth*, in anatomy, differs from the ordinary acceptation of the term, which is usually applied, not to the buccal cavity, but to its orifice.

† As a general rule, the proportion between the different parts of the alimentary canal is such, that the upper portion will not admit bodies too large for the lower; and though the buccal cavity forms an exception to the rule, it is because the food, whilst it remains in that situation, is under the influence of the will.

In man, the *direction* or *axis* of the mouth is horizontal— an arrangement which is connected with his destination for the biped position. If man assumed the attitude of a quadruped, the axis of his mouth would be vertical; whereas, in the lower animals, it is directed obliquely to the horizon.

Form. The mouth (*fig.* 140.) represents a perfectly symmetrical oval cavity, the great extremity of which is in front. It has an *upper wall*, viz. the arch of the palate (*a*); a *lower wall*, consisting principally of the tongue (*b*); a *posterior wall*, formed by the velum palati (*c*); an *anterior wall*, composed of the lips (*d*) on one plane, and of the alveolar arches and the teeth (*e*) on another; and two *lateral walls*, formed by the same arches, by the teeth, and by the cheeks. It has two openings —one *anterior* (*m*), constituting the orifice of the mouth; the other *posterior* (2, *figs.* 140, 141.), establishing a communication between the buccal cavity and the pharynx, and on account of its narrowness called the *isthmus of the fauces*.

We shall now describe these parts in succession, excepting the maxillary bones and the teeth, which have been already treated of. The salivary glands which pour their secretions into the buccal cavity will be described as appendages to it.

The Lips.

The *lips*, forming the anterior wall of the mouth, are two moveable, extensible, and contractile curtains, which circumscribe its orifice. They are distinguished into *upper* and *lower*. Their *direction* is vertical like that of the alveolar and dental arches upon which they are applied. This direction is peculiar to the human species, and is more marked in the Caucasian race; lips projecting forwards, like those of the lower animals, and not placed upon the same vertical plane, give a mean expression to the physiognomy. The depth of the lips is measured by that of the alveolar and dental arches. The upper is deeper than the lower lip.

The two lips offer for our consideration an anterior or cutaneous surface, a posterior or mucous surface, an attached and a free border, and two commissures.

The anterior surface. In the *upper lip* this surface presents along the *median line* a vertical furrow, the *sub-nasal groove*, commencing at the septum of the nose, and terminating below in a tubercle, which is more or less prominent in different individuals. This furrow is the vestige of a division in the lip, natural to many mammalia. The malformation, termed single *hare-lip*, always occupies one of the edges of this groove; in double hare-lip both of them are affected. *On each side*, the upper lip is convex, and covered with a slight down in the female, and before puberty in the male, but after that period with long and stiff hairs directed obliquely outwards. The aspect of the anterior surface of the *lower lip* is inclined a little downwards; the middle portion only of this lip, which presents no median depression, is covered with hairs.

The posterior surface. Each lip is free behind excepting in the median line, where we find a small fold of mucous membrane called the *frænum labii*: it is more marked in the upper than in the lower lip. This surface is always moist, and is in contact with the alveolar and dental arches. The complete independence of the lips, as regards the maxillary bones, explains the extreme mobility of these membranous organs.*

Adherent borders of the lips. The lips are bounded at their posterior surface by the reflection of the mucous membrane upon the jaw, so that there is a deep and very remarkable furrow between the lips and the maxillary bones, which may be regarded as an *anterior buccal cavity*, or the *vestibule* of the mouth. The upper lip is bounded in front by the base of the nose; on each side it is separated from the cheeks by the projection of the inner margin of the levator

* Mammalia alone have lips that are moveable, independently of the jaws; but this independence is still more marked in man.

labii superioris alæque nasi: the lower lip is bounded in the median line by a transverse depression situated between it and the chin, called the *mento-labial* furrow, which is remarkable for the perpendicular direction of the hairs growing upon it; on each side it is separated from the cheeks by the projecting inner margin of the triangularis oris.

The line or furrow which separates on either side the lips from the cheek commences at the ala of the nose, and is called the *naso-labial line* *: it would be more appropriately named the *bucco-labial line* or *furrow*.

The boundaries between the lips and the cheeks are then entirely artificial: the two lips, taken together, represent an ellipse, the longest diameter of which is transverse.

The free borders of the lips. The free borders of the lips are rounded, are covered by a red integument intermediate in character between skin and mucous membrane, and are marked by folds or wrinkles directed at right angles to the length of the lips, and produced by the contraction of the orbicularis oris muscle. These free borders, which are as it were everted, especially that of the lower lip, present anteriorly a well-marked line of separation between the skin and the mucous membrane; they describe an undulating line, which attracts the attention of the painter more than that of the anatomist.

The chief characters of the free margin of the upper lip are, a slight projection in the middle line, and a slight depression on either side: those of the free border of the lower lip are a median depression and two lateral projections; on meeting together, these borders come into accurate contact, and completely close the opening of the mouth. The free margins of the lips are, moreover, their thickest part, and they are thicker in the middle than at each extremity; their thickness also varies greatly in different individuals. In general, thick lips are regarded as indicating a scrofulous diathesis; but in forming an opinion upon this subject, it is necessary to distinguish carefully between size resulting from hypertrophy of the muscular layer, and that which is caused by an excess of skin and cellular tissue. In the Ethiopian race, the size of the lips is entirely due to the great developement of the muscles.

The commissures. The lateral extremities of the free margins of the lips are thin, and by their union form the *angles* or *commissures* of the lips (from *committo*, to join together).

The anterior orifice of the mouth. The free edges of the lips intercept a transverse fissure, viz. the *anterior opening of the mouth.* The variable size of this orifice in man has given rise to the distinctions of *middle-sized*, *large*, and *small* mouths: the difference, however, is confined to the opening, and does not at all affect the buccal cavity properly so called. The anterior opening of the lips is also exceedingly dilatable, and accordingly admits the introduction of very large bodies, and renders the exploration of every part of the cavity of the mouth comparatively easy.

Structure of the lips. The lips are composed of two tegumentary layers, one cutaneous, the other mucous; of a muscular layer; of a series of glands; and of vessels, nerves, and cellular tissue.

The cutaneous layer. This is remarkable for its density and thickness, for the size of the hair follicles, which are partially situated beneath it, and for its intimate adhesion to the muscular layer; so that it is impossible to separate them by dissection without encroaching upon one or the other. This layer may be regarded as the framework of the lips. It is endowed with an exquisite sensibility, and, in many animals, possesses so delicate a sense of touch, that the slightest movement of the extremities of the long hairs with which it is provided, at once warns the animal of the presence of approaching objects.

The mucous layer. This is remarkable from the existence of an epithelium upon it, which can be very easily demonstrated. It covers the free edge of

* Much importance is attached to this furrow in semeiology. It is termed the abdominal line, because it becomes remarkably distinct in diseases of the abdomen

the lips, so that by a rare exception a portion of this mucous membrane is habitually exposed to the external air. It adheres more firmly at the free edge of the lip than elsewhere.*

The glandular layer. This is a thick layer, situated between the mucous and the muscular layers, and causing an elevation of the former. It consists of small spheroidal glands, of unequal size, placed close to each other, but perfectly distinct; when examined with a lens they resemble small salivary glands, each being provided with an excretory duct, opening by a separate orifice upon the posterior surface of the mucous membrane.† These are true *labial salivary glands*, and not muciparous follicles.

The muscular layer. This is composed essentially of a single proper muscle, the orbicularis oris, into which almost all the muscles of the face are inserted, viz. the levator labii superioris alæque nasi, the levator labii superioris, the depressor alæ nasi, the naso-labialis, and the zygomaticus minor (where it exists) for the upper lip; the quadratus menti and the levator labii inferioris for the lower lip; the buccinator (which we have regarded as forming the orbicularis by its bifurcation extending to both lips), and the zygomaticus major, the triangularis oris, the levator anguli oris, and the risorius of Santorini (where it exists) to the commissures. Including the orbicularis oris, there are twenty-five muscles. The differences presented by the free edges of the lips in different individuals depend upon variations in the thickness of the corresponding portion of the orbicularis.

No fibrous tissue enters into the composition of the lips and their commissures, which are exclusively formed of fleshy fibres: hence they are extremely extensible, a circumstance of which the surgeon avails himself in operating upon parts situated in the buccal cavity and pharynx.

Vessels, nerves, and cellular tissue. Few parts are so abundantly provided with vessels and nerves as the lips. The *arteries* of the lips are derived from two principal sources: the *coronary arteries* arise from the facial; the buccal, infra-orbital, and alveolar arteries destined for the upper lip, and the mental artery for the lower lip, arise from the internal maxillary. The sub-mental artery, a branch of the facial, and the transversalis faciei, a branch of the temporal, also give off some ramifications to the lips. The *veins* bear the same names, and follow the same direction as the arteries; the lymphatic vessels, which are little known, terminate in the glands at the base of the jaw. The *nerves* are derived from two distinct sources, viz. from the fifth and the seventh pairs of cranial nerves.

The *cellular tissue* contained in the substance of the lips is essentially of a serous nature. It is liable to a considerable amount of serous infiltration; but even in the fattest individuals, it contains only a very small quantity of adipose tissue.

Developement. According to Blumenbach and most modern anatomists, the upper lip is originally developed from three points or three distinct parts—one median and two lateral. Some have even gone further, and have maintained that the median point itself is originally formed of two lateral halves, which become united at a very early period. This hypothesis is founded partly upon the nature of the divisions in simple and double hare-lip, each of which has been assumed to be nothing more than an arrest of devolopement; also, upon the mode of developement of the superior maxillary bones, the alveolar border of which, it is said, is composed of four pieces—two median or incisor, and two lateral; and lastly, upon the permanent existence of these divisions in some animals. In opposition to this view, however, we may state, first, the absence in the human fœtus of distinct bony pieces, corresponding to the ossa incisiva of the lower

* [The mucous membrane upon the free borders of the lip is provided with papillæ. Its epithelium, and, indeed, that of the entire mouth, is *squamous*.]

† When these orifices are obliterated, the dilated excretory ducts are transformed into salivary cysts, which may acquire a very large size.

animals, for all that can be distinguished is a fissure, the mere trace of a separation (see *Developement of the Superior Maxilla*, p. 70.); and secondly, that at no period of fœtal life can we demonstrate the existence of any division in the upper lip. This lip has always appeared to me to consist of a single piece, from the earliest period of its formation. The same may be said of the lower lip, which, according to authors, is developed from two lateral halves. At no period of fœtal life can any such division be detected.* I do not even know an example of malformation in which such an arrrangement existed.

The length of the lips of the new born infant is well adapted for the act of sucking, and depends upon the absence of the teeth. To the same cause, and to the wasting of the alveolar borders, the length of the lips in advanced age must be referred.

Uses. The lips, constituting the anterior wall of the mouth, form a sort of barrier in front of the teeth, and alveolar arches, by which the saliva is retained within that cavity. So great is the importance of the lips in preventing a continual escape of the saliva, that in cases where they have been destroyed, the constant draining away of that fluid may become a cause of exhaustion and even of death.†

They are employed, also, in drinking, sucking, and blowing; in playing upon wind-instruments, and in uttering articulate sounds. They are also of great importance in the expression of the passions, which, as we have seen, influence all the muscles of the face. Pride, contempt, joy, grief, anger, and every possible gradation of feeling, are depicted in a striking manner upon the outline of the lips. The mouth is more particularly the seat of grimaces, which are nothing more than the expression of passions ridiculously exaggerated.

The Cheeks.

The *cheeks* form the lateral walls of the mouth and the sides of the face. They are bounded internally by the reflection of the mucous membrane upon the maxillary bones: externally their limits are much less defined, and are thus determined on each side of the face; in front, by the *bucco-labial* furrow, which separates them from the lips; behind, by the posterior border of the ramus of the lower jaw; above, by the base of the orbit; and below, by the base of the lower jaw. The cheeks then comprise three very distinct regions: the malar, the masseteric, and the buccal, properly so called. Each cheek is quadrilateral in form, and presents, 1. an *external* or *cutaneous surface* on which is observed, above, the projection of the cheek, called the *malar eminence*, and lower down, a surface, which is convex and smooth in stout persons, but hollow and wrinkled in the emaciated; 2. an *internal* or *mucous surface*, free and corresponding to the alveolar and dental arches. On this surface is situated the orifice of the Stenonian duct, opposite the interval which separates the first from the second upper large molar tooth.

Structure. Each cheek, properly so called, is composed of the following parts: the malar bone and the ramus of the lower jaw; a cutaneous layer, increased in thickness by a great quantity of fat; a mucous, a glandular, a muscular, and an aponeurotic layer; some vessels and nerves, and an excretory duct. We shall make a few remarks upon these different layers, commencing with the skin.

The *skin* is remarkable for its firmness and vascularity over the cheek bone, and also for the facility with which it is injected, or becomes pale under the influence of the moral feelings: it is covered with hair on the lower and back part in the adult male.

* The admirable researches of M. Velpeau upon embryology fully confirm the results at which I have arrived.

† This use is principally confined to the lower lip, and it is remarkable that this lip is never affected by congenital fissure. Another singular and also totally inexplicable fact is, that cancer, which is so common a disease, never affects the upper, but invariably the lower lip.

The *mucous membrane* is a continuation of that of the lips, and presents the same characters.

The *glandular layer* is formed by the *buccal salivary glands*, which exactly resemble the labial glands, but are smaller, and like them cause projections of the mucous membrane, upon which they open by distinct orifices. Two of these glands have obtained a particular appellation, because they are not subjacent to the mucous membrane, but are situated between the buccinator and the masseter muscles: they are called the *molar glands*. Their excretory ducts open opposite the last molar tooth.

The *muscular layer* is formed, in the masseteric region, by the masseter and a part of the platysma; in the malar region, by the orbicularis palpebrarum; in the buccal region, properly so called, by the buccinator, and the two zygomatici.

The *aponeurotic layer* is formed by the aponeurosis of the buccinator muscle.

The *adipose layer* is thin in the malar and masseteric regions, and very thick in the buccal region, properly so called. Bichat has, moreover, pointed out a *mass of fat* in the substance of the cheek, between the buccinator and the masseter. It is highly developed in the infant, and vestiges of it are found even in the most emaciated individuals, and in extreme old age.

The *arteries* of the cheeks come, partly, from the facial and the transverse artery of the face, and partly from the internal maxillary: the branches from the internal maxillary belong to the infra-orbital, the inferior dental, the buccal, the masseteric, and the alveolar arteries.

The *veins* bear the same name, and follow the same course as the arteries.

The *lymphatic* vessels pass into the cervical and parotid lymphatic glands.

The *nerves* of the cheeks, like those of the lips, are derived from two sources, viz. the buccal and malar nerves, from the portio dura of the seventh pair, and the buccal, masseteric, infra-orbital, and mental branches of the fifth pair.

The cheek is perforated by the *duct of Steno* (*s*, *fig.* 144.), which runs horizontally forwards below the malar bone.

Developement. The absence of the teeth, the presence of a large quantity of fat (more especially the great size of the mass above noticed), the want of height in the superior maxilla, from the non-developement of the sinus, and lastly the obtuse angle of the lower jaw, give to the cheek of the infant its characteristic fulness. The loss of the teeth and the wasting of the alveolar borders in the aged diminish the inter-maxillary space; so that their emaciated cheeks become disproportionately long, and consequently display a looseness, which forms one of the chief peculiarities in their physiognomy. At puberty, the cheeks of the male are covered with hair.

Uses. The cheeks form lateral active walls of the mouth, which, closely applying themselves against the alveolar arches and teeth, force the food between the latter, and thus assist in mastication. They are employed, also, in suction, in the articulation of sounds, and in playing upon wind-instruments. In the expression of the passions they assist rather by changes in their colour, than by any distinct movements.

The cheeks and the lips constitute the outer wall of a supernumerary buccal cavity, of which the inner wall is formed by the alveolar borders and the teeth. This cavity, a sort of vestibule to the buccal cavity, properly so called, is very dilatable. It may be considered as a kind of reservoir, in which the food is deposited, in order to be submitted in successive portions to the action of the masticatory organs. This vestibular buccal cavity is provided with labial and buccal salivary glands. It is also interesting to find that the parotid glands, the largest of all the salivary glands, pour their secretion into this cavity.

The Palatine Arch and the Gums.

The *palatine arch*, or the hard *palate* (*a*, *fig.* 140.), constitutes the upper wall of the buccal cavity. It has the form of a parabolic arch, bounded in front and on either side by the teeth, and behind by the velum palati, into which it is continued without any distinct line of demarcation. Upon it we observe, in the median line, an antero-posterior *raphè*, at the anterior extremity of which is a tubercle corresponding to the lower orifice of the anterior palatine canal. This tubercle has been incorrectly stated by physiologists to be endowed with a peculiar sensibility; on each side and in front there are transverse ridges, more or less marked in different individuals, which represent the still more highly developed ridges, bars, or calcareous concretions, which render the surface of the roof of the palate in some animals so rugged. Posteriorly the roof of the palate is perfectly smooth.

Structure. The constituent parts of the palatine arch are, an osseous framework, a fibro-mucous membrane, a layer of glands, with vessels and nerves.

The framework consists of the bony palate already described: it is thicker in front than behind, and is held up in the middle by the sort of column formed by the vomer and the perpendicular plate of the ethmoid, and behind and on each side by the vertical portions of the palate bones, and by the pterygoid processes. We have already noticed the asperities which it presents, and which appear to have no other object than to secure the intimate adhesion of the fibro-mucous membrane to the bones.

The palatine and gingival membrane. This mucous membrane is remarkable for its whitish colour; for the thickness of its epithelium, especially in front; for the thickness and density of its chorion, which even approaches to that of the corresponding tissue in the skin; for its close adhesion to the bones, into which the chorion sends off well-marked fibro-cellular prolongations; and lastly, for the great number of orifices with which it is perforated, especially behind. This excessive thickness of the palatine membrane, however, is observed only anteriorly, and most particularly so behind the incisor teeth.

The glandular layer. In the median line the palatine membrane is blended with the periosteum of the bones, but on each side it is separated from it by a very thick layer of glands, which are sometimes arranged in regular rows along the antero-posterior groove presented by the palatine arch. These *palatine salivary glands* are exactly similar to the labial and buccal glands already described; they are much more numerous behind than in front, and open upon the membrane by a number of orifices, visible to the naked eye. There are often two openings much more distinctly marked than the rest, situated one on either side of the posterior extremity of the median raphé.

The gums. The description of the peculiar tissue of the *gums*, to which some allusion has been made in speaking of the teeth, naturally follows that of the palatine membrane. The term gums (οὐλὰ) is applied to those portions of the buccal mucous membrane which surround the teeth. They are distinguished from the rest of that membrane by their intimate adhesion to the periosteum, by their thickness, and especially by their almost cartilaginous density, which enables them to resist the shocks of hard bodies during mastication. In this latter respect, and in regard to their want of sensibility, the gums closely resemble the contiguous portions of the palatine membrane. They commence about a line from the base of the alveoli, their limits being marked by a scalloped ridge. Having reached the free margins, *i. e.* the base of the alveoli, the gums continue their course for the space of about a line beyond that point, as far as the neck of the teeth, where they become reflected upon themselves. The point of reflection is a free border of a semilunar shape, corresponding to the indented, and as it were festooned, border of each alveolus. The denticulations or longest portions of the gums correspond to the intervals between the teeth, in which situation the processes of the gum,

covering the anterior and posterior surfaces of the alveoli, communicate with each other.

The *reflected portion* of the gum, though not adhering to, is in contact with, all that portion of the root of the tooth which projects above the alveolus; it then dips into the cavity of the latter, so as to form the *alveolo-dental periosteum*, which, as we have already seen, is a powerful means of connecting the fang of the tooth to its socket. The tissue of the gums appears to be provided with particular follicles for the secretion of the tartar.* It varies much in different individuals, both in colour and in density. One of its most peculiar characters is the singular effect produced on it by scurvy and by mercury, under the influence of which agents it becomes softened and fungous, easily bleeds, and furnishes a large quantity of tartar.* Another, but purely anatomical character consists in its largely developed openings or pores, which in a particular light are even visible to the naked eye. The gums are almost insensible when divided by cutting instruments; but the pressure exerted upon them by the teeth during the eruption of the latter, often gives rise to the most serious affections.

Vessels and nerves of the roof of the palate and the gums. The *arteries* arise, some from the internal maxillary, viz. the posterior palatine, the alveolar, the infra-orbital, and the mental branches; others from the facial, viz. the superior coronary for the gums of the upper, and the sub-mental branches for those of the lower jaw; the sublingual artery also supplies the latter. The *veins* bear the same name. All the *nerves* proceed from the fifth pair, viz. the palatine and the superior and inferior dental branches. The naso-palatine nerve sends ramifications to the small median tubercle upon the roof of the palate. Few parts have so little cellular tissue as the gums.

Developement. According to the best authorities the bony and membranous portions of the hard palate are developed from two laterol points which unite along the median line, so that the malformation, known by the name of hare-lip with cleft palate, is said to be an arrest of developement. The fissure may be either single or double in front. If the cleft be double, that portion of the upper jaw, which supports the incisor teeth, is separated on both sides from the rest of the bone. Such divisions always seem to me to be absolutely departures from nature †, for at no period of its growth can such separations or clefts be detected in a naturally formed fœtus.

Uses of the gums and hard palate. The hard palate separates the buccal cavity from the nasal fossa. It serves as a fulcrum for the tongue in the act of tasting, in mastication, deglutition, and the articulation of sounds. Before the eruption of the teeth, the gums completely close the alveoli and serve as the immediate instruments of mastication; and they become hard, and supply the place of the teeth after the loss of those organs. The gums have great influence in fixing the teeth within their sockets, and hence the loosening of the former from scurvy or from the abuse of mercury. We may consider the gums as that portion of the mucous membrane in which the dental follicles are situated.

The Velum Palati and Isthmus Faucium.

Dissection. The lower surface of the velum palati may be seen by forcibly depressing the lower jaw, or still better by sawing it across in the median line, and separating the two halves. In order to see its upper surface, the pharynx must be removed entire, and its posterior wall divided vertically (as in *fig.* 141.). The dissection of the different layers which enter into the formation of the velum palati, and of its extrinsic and intrinsic muscles, will be understood from the following descriptions: —

* [These are mucous follicles: the tartar is now known to be merely a deposit from the saliva its increased amount during mercurial salivation is, therefore, readily accounted for.]

† [*I.e.* not mere arrests of developement.]

External conformation. The *velum palati*, or *soft palate* (*c*, *fig.* 140.), is a muscular and membranous valve, which prolongs the palatine arch backwards, and therefore might be called the *membranous palatine arch.* It is a sort of incomplete septum (septum staphylin, *Chauss.*), dividing the buccal cavity from the nasal fossæ and the pharynx.

Its *direction* is curved: its upper portion is horizontal, but it soon becomes curved and passes almost directly downwards (velum *pendulum* palati). In the act of deglutition, the velum becomes horizontal during the passage of the alimentary mass, but immediately afterwards returns to its oblique and pendulous position, and thus tends to prevent the return of the food into the mouth. In several pathological conditions the velum is thrown backwards and upwards, and adheres to the posterior orifices of the nasal fossæ. All these changes of direction affect the oblique and not the horizontal portion of the velum. The velum palati is broad, quadrilateral, and perfectly symmetrical. Its *inferior* or *buccal surface* is concave, and continuous with the hard palate without any line of demarcation. This surface is very well seen when the mouth is opened, and is therefore easily accessible to the surgeon. In the median line it presents a white raphé, which is a continuation of the median raphé of the hard palate; it is formed by a small fibrous cord, causing a projection under the mucous membrane.

The *superior* or *nasal surface* of the velum (*fig.* 141.) is convex: it prolongs the floor of the nasal fossæ, and, from its obliquity, directs the mucus into the pharynx. This surface presents a median projection produced above by the palato-staphylin muscles (azygos uvulæ (*a*)), and below by a mass of glands. Congenital division of the velum is always situated in the median line, and is followed by so great a retraction of its two halves, that, in some cases, the entire absence of the velum has been suspected.

Its *upper border* is thick, and firmly united to the posterior border of the hard palate.

Its *lower border* is free, extremely thin and concave, and forms the upper boundary of the isthmus (*t*, *fig.* 141.) of the fauces: it presents, in the middle line, a sort of appendix or prolongation, call the *uvula* (*u*, *fig.* 140.): this is of a conical shape, and of very variable size and length; it is capable of considerable elongation, and may then reach the base of the tongue, but not, as has been supposed, the upper orifice of the larynx.* It is not very uncommon to find it bifid, and sometimes it is entirely wanting.

The two *lateral* borders of the velum limit it on each side, and separate it from the cheek. This boundary is indicated (on each side) by a prominent ridge (before *f*, *fig.* 140.), extending from the posterior extremity of the upper to the corresponding part of the lower alveolar border. This prominence corresponds to the anterior margin of the internal pterygoid muscle, and is formed in a great measure by a series of small glandular structures, which are collected behind the last great molar tooth of the lower jaw into a considerable mass resembling a small gland.

The *pillars* of the *velum palati.* These are two *lateral* columns or *pillars*, having an arched form, and distinguished into *anterior* (behind *f*, *fig.* 140.) and *posterior* (*g*), which pass down on either side from the uvula. Each of the *anterior pillars* (the two forming together the anterior arch of the fauces) proceeds from the base of the uvula outwards, and then vertically downwards, describing a curve with its concavity directed inwards, and terminates at the sides of the tongue, opposite the anterior extremities of the V-shaped series of papillæ vallatæ found upon that organ. Each of the *posterior pillars* (which together form the posterior arch of the fauces) commences at the apex of the uvula, and immediately curves into an arch, having a smaller diameter than that

* In consultation upon a case of chronic laryngitis, I was much surprised to hear the medical attendant state that the disease was the result of irritation produced by the uvula upon the superior orifice of the larynx. The position of the uvula is always a few lines in advance of the epiglottis.

represented by the anterior pillar, and then passes obliquely downwards, backwards, and outwards, to its termination on the sides of the pharynx. The two posterior pillars constitute the free margin of the velum. They project much farther inwards than the anterior pillars, so that when the base of the tongue is depressed in the living subject, both sets of pillars can be seen at the same time, like double curtains, placed on different planes. Each of these pillars represents a triangle, having its base below and its apex above.

The amygdaloid fossa. From the direction of the anterior and posterior pillars they approach each other above, and are separated by a considerable interval below. This interval, which is partly occupied by the tonsil (*n*), may be called the *amygdaloid excavation*. In order to have a good idea of it, it is necessary to make a vertical section of the head from before backwards. A sort of recess will then be observed, narrow and shallow above, but very broad and deep below, especially when the tonsil (*n*) is small. The base of this fossa corresponds anteriorly to the base of the tongue (*b*), then to the epiglottis (*i*), the larynx, and the walls of the pharynx: the bottom of the fossa corresponds to the angle of the lower jaw and the lateral portion of the supra-hyoid region, where it is separated from the skin only by a thin layer of soft tissues. The dimensions of this fossa always remain the same above, but are very variable below, according as the tongue is retained in the mouth or protruded.

The isthmus faucium. The posterior orifice of the buccal cavity is called the *isthmus faucium* (2, *figs.* 140, 141.). It is a sort of passage between the buccal and the pharyngeal cavities, bounded below by the base of the tongue, above by the free margin of the velum palati, divided into two arches by the uvula in the middle, and the two pillars on each side. This posterior orifice of the mouth, though very dilatable, is less so than the anterior opening of the same cavity. It may be contracted, and even completely closed, not only from inflammation of the tonsils and arches of the fauces, but also from the contraction of the muscles which enter into the formation of the velum and its pillars. This may be seen by watching the movements of the isthmus of the fauces, in a person who will submit to such an examination. These differences in the dimensions of the isthmus are concerned not only in deglutition, but also in the modulations or articulations of the voice.

Structure. In the velum palati we find an aponeurotic framework; also certain muscles by which it is moved, which are either extrinsic or intrinsic. The intrinsic muscles are those constituting the azygos uvulæ, viz. the palato-staphylini; and the extrinsic muscles are four on each side, two descending, viz. the levator palati, and the circumflexus or tensor palati, and two ascending, viz. the palato-glossus and the palato-pharyngeus. We also find in the soft palate a thick layer of glands, vessels, nerves, and cellular tissue; and lastly, a covering of mucous membrane.

The aponeurotic portion. The aponeurotic portion, or rather the principal aponeurosis, is extremely dense, and continues the hard palate backwards: it is generally regarded as an expansion of the reflected tendons of the tensores palati, but it is in a great measure formed of proper fibres continuous with the fibrous tissue, which prolongs backwards the septum narium, the outer borders of the posterior orifices of the nasal fossæ, and the fibrous portion of the Eustachian tube. Below this aponeurotic membrane there is another *fibrous lamella*, continuous with the fibrous tissue found in the hard palate. The framework of the upper half of the velum palati may therefore be said to be formed of two fibrous layers, one superior, the other inferior, between which the glandular layer is situated. Lastly, a small fibrous band extends from the nasal spine to the uvula, along the median raphé upon the lower surface of the velum, producing a slight elevation of the mucous membrane. This little band sends off a prolongation between the glands of the velum, which separates the right half of the soft palate from the left.

The Muscles of the Velum Palati.

Dissection. This is common to all the muscles of the soft palate. It is merely necessary to remove the mucous membranes and the subjacent glands, in order to study the arrangement of these muscles, and to follow the ascending and descending fibres which emerge from or enter into the velum.

The Azygos Uvulæ, or Palato-staphylini.

The palato-staphylini (*a*, *fig*. 141.) are two small, fleshy, cylindrical bands placed in contact, one on each side of the median line, and extending from the posterior nasal spine, or rather from the aponeurosis continuous with it, to the base of the uvula. They are covered by the mucous membrane of the nose, under which they form a projection, and they cover the levatores palati. The two muscles, from their juxtaposition, appear, at first sight, to form a single rounded muscle, to which the names, *azygos uvulæ*, *columellæ musculus teres*, have been given.

Fig. 141.

Action. To raise the uvula.

The Levator Palati, or Peristaphylinus Internus.

Dissection. Remove the mucous membrane from a vertical ridge which exists along the outer border of the posterior orifice of one of the nasal fossæ, behind the Eustachian tube; then remove the mucous membrane covering the upper surface of the soft palate.

The vertical portion of the *levator palati* (le petro-salpingo staphylin, *Winslow;* petro-staphylin, *Chauss*., *c*, *figs*. 141. 146.) is situated upon the outer side of the posterior orifice of the corresponding nasal fossa; its horizontal portion is in the substance of the velum: it is thick, narrow, and rounded above, expanded and triangular below. It *arises* by short tendinous fibres from the lower surface of the petrous portion of the temporal bone near its apex, and from the contiguous part of the cartilage of the Eustachian tube. From these points its fibres pass obliquely downwards and inwards, turning round the outer side of the tube. At the outer border of the velum palati the muscle becomes horizontal, and its fasciculated fibres diverge, so as to cover the whole extent of the antero-posterior diameter of the velum.

The anterior fleshy fasciculi are *inserted* by short tendinous fibres into the posterior border of the aponeurosis of the soft palate. The others also terminate by very short tendinous fibres, which are blended in the median line with those of the opposite side, immediately below the azygos uvulæ.

Relations. It is covered by the mucous membrane of the pharynx and soft palate; its vertical portion is in relation, on the outside, with the circumflexus palati and the superior constrictor muscles, and its horizontal portion with the palato-pharyngeus. It forms the uppermost muscular layer of the soft palate.

Action. It raises the velum (elevator palati mollis, *Albin*., *Soemm*.). The length of its fibres, its direction, and its shape, render it well fitted for this purpose. It should be remarked that the tendinous portion of the velum scarcely participates in the movement of elevation.

The Circumflexus or Tensor Palati, or the Peristaphylinus Externus.

This is a thin, flat, and reflected muscle (le pterygo- or spheno-salpingo staphylin, *Winsl.;* pterygo-staphylin, *Chauss.*), and is tendinous for a considerable

part of its extent; its vertical portion (*d*, *fig.* 141. 146.) is situated along the internal plate of the pterygoid process, to the inner side of the internal pterygoid muscle (*b*), and its horizontal portion (*d*) in the substance of the velum.

Attachments. It *arises* from the fossa navicularis, at the base of the internal pterygoid plate, from the contiguous part of the great wing of the sphenoid, and from a small portion of the cartilage of the Eustachian tube. From these points the muscle, which forms a thin fasciculus, flattened at the side, passes vertically downwards: near the hamular process of the internal pterygoid plate it becomes a shining tendon, which changes its direction, and is reflected at a right angle under that process: it is retained in this situation by a small ligament, and its motions are facilitated by a synovial membrane. The tendon then passes horizontally inwards, expands, and becomes blended with the aponeurotic membrane.

Relations. Its vertical portion is in relation on the outside with the internal pterygoid, and on the inside with the levator palati, from which it is separated by the superior constrictor of the pharynx (*g*, *fig.* 141.) and by the internal pterygoid plate. Its horizontal or aponeurotic portion is anterior to the levator palati, and has the same relation as the aponeurotic portion of the velum.

Action. It is a tensor of the aponeurotic portion (*tensor palati*), but does not otherwise move the velum. As Haller has remarked, when its fixed point is below, it can dilate the Eustachian tube.

The Palato-pharyngeus, or Pharyngo-staphylinus.

This muscle (thyro-staphylinus, *Douglas*, *e e*, *fig.* 141.) is narrow and fasciculated in the middle, where it is situated in the posterior pillar of the fauces, broad and membranous at its extremities, one of which is in the velum and the other in the pharynx.

Attachments. It arises from the whole extent of the posterior border of the thyroid cartilage. From this point it passes vertically upwards, and forms a broad and thin muscular layer, the fibres of which are first collected into a fasciculus or muscular column, which enters the posterior pillar of the fauces, and then again expanding occupy the whole extent of the antero-posterior diameter of the velum, and unite in the median line with the muscle of the opposite side, so as to form an arch. The anterior fibres are *inserted* into the posterior border of the aponeurosis of the velum.

Relations. It forms the lowest muscular stratum of the velum: it is separated from the mucous membrane below by the layer of glands: it is in relation above with the muscular layer formed by the expansion of the levator palati. In the posterior pillar it is in relation with the mucous membrane, which covers it in all directions, excepting on the outside. In the pharynx it forms the innermost muscular layer, *i. e.* it lies between the constrictors and the mucous membrane.

Action. The two palato-pharyngei draw the velum downwards, and press it strongly against the alimentary mass during deglutition; they therefore form a constrictor of the isthmus of the fauces. When they take their fixed points above, they raise the posterior wall of the pharynx. They are important agents in deglutition.

The Palato-glossus, or Glosso-staphylinus.

This is a small fleshy bundle (*o*, *fig.* 141.) situated in the anterior pillar of the fauces, narrow in the middle, and broad at the extremities. Its lower extremity is expanded upon the side of the tongue, and is united with the stylo-glossus. Its upper extremity spreads out in the velum palati, and becomes blended with that of the palato-pharyngeus. Its middle portion is very slender; it forms the anterior pillar, and is visible through the thin mucous membrane by which it is covered.

Action. The two muscles depress the velum palati, and raise the edges of the base of the tongue; they consequently constrict the isthmus faucium.

The glandular layer of the velum palati. Under the mucous membrane covering the upper surface of the velum palati, there are some scattered glands, which are more numerous on the sides than along the middle. But on the lower surface of the velum there is a much more obvious collection of glands, particularly dense, opposite the aponeurotic portion of the velum, and forming a continuation of the glandular layer of the hard palate. Similar glands are found in the uvula, the size, and in some measure the form, of which they determine. These small glands in the velum exactly resemble the salivary glands already described as existing in the lips, the cheeks, and the roof of the palate.

The mucous membrane. Both surfaces of the velum are covered by mucous membrane, which constitutes, as it were, its integuments. These two mucous layers are remarkable, inasmuch as each presents the peculiar characters of the cavity to which it belongs. Thus the lower layer preserves the characters of the buccal mucous membrane, and the upper layer those of the nasal.* The two layers are continuous with each other along the free margin of the velum palati; the fold of mucous membrane, forming this margin, passes beyond the other constituent tissues, so that for the space of half a line or a line the two mucous layers are in contact. The same occurs in the uvula, the apex, and sometimes the lower half of which consists of a duplicature of mucous membrane, containing some loose cellular tissue, which is very susceptible of infiltration. Either serous or sanguineous infiltration of the uvula produce an elongation of this part, called *relaxation* of the uvula. I should not omit to mention the great difference, in regard to sensibility and liability to inflammation, that exists between the mucous membrane of the free and adherent borders of the velum palati.

Vessels and nerves. These are very numerous in proportion to the size of the part. The *arteries* arise from the palatine and the superior and inferior pharyngeal. The *veins* are similarly named, and follow the same course. The *lymphatic vessels*, which have been little studied, enter the lymphatic glands at the angle of the jaw. The *nerves* are derived from the palatine branches given off by Meckel's ganglion, and from the glosso-pharyngeus.

Developement. We have here again the question, whether the velum is formed originally from two halves, which afterwards become united in the median line: in favour of this view we may adduce those cases in which the uvula and the velum are bifid, either with or without fissure of the hard palate and lip. In the youngest embryos which I have examined, I have always found the velum undivided.

Uses. The velum palati is a contractile valve, which fulfils very important functions in deglutition, in the utterance of articulate sounds, and in the modulation of the voice; it is capable of being elevated and depressed. Elevation affects its muscular, but not its aponeurotic, portion: this movement cannot be carried so far as to revert the velum upwards. Depression may be carried to such an extent as to close the isthmus faucium by the approximation of the velum and the base of the tongue. The contraction of the palato-pharyngei, which are curved muscles, may be so complete as to bring the posterior pillars of the fauces into contact, and thus close the isthmus in a transverse direction. The uvula moves independently of the velum. When the aponeurosis of the velum palati is rendered tense, the velum itself is enabled to resist both elevation and depression.

* [According to the recent researches of Dr. Henlé, the ciliated columnar epithelium (like that of the nasal mucous membrane) is found upon the upper surface of the velum, only in the neighbourhood of, and a short distance below, the expanded orifice of the Eustachian tube; the remaining portion of the upper surface, as well as the free border, and the whole of the lower surface, are covered with the squamous epithelium, similar to that of the buccal mucous membrane.]

The Tonsils, or Amygdalæ.

The terms *amygdalæ* (ἀμυγδαλέα, an almond) or *tonsils*, are applied to a group of mucous follicles (*n*, *fig.* 140.), which occupy the interval between the pillars of the fauces on each side. They are placed there on account of the necessity of lubricating the isthmus during the passage of the alimentary mass. Their form pretty nearly resembles that of an almond; they are directed obliquely downwards and forwards, and their size is exceedingly subject to either congenital or accidental variation. In some subjects they can scarcely be said to exist; in others they fill up the whole amygdaloid fossa, and project more or less into the isthmus of the fauces, so as to impede deglutition, or even respiration.

The compound tonsil results from its component follicles being collected into several distinct masses.

The *internal surface* is free, and may be seen when the base of the tongue is depressed; it is perforated by foramina, like the ligneous shell of an almond. These foramina, which vary in number and size, have been frequently mistaken for syphilitic ulcerations. They lead into small cells, in which mucus sometimes collects, and is then ejected in hard fetid lumps, which have been erroneously supposed to be pulmonary tubercles. Its *external surface* is covered immediately by the aponeurosis of the pharynx*, and then by the superior constrictor.

The tonsil corresponds to the angle of the lower jaw. Compression behind this angle, therefore, affects it at once, and causes pain in cases where it is inflamed. It has an important relation with the internal carotid artery, especially when that vessel describing a curve with the convexity directed inwards touches the tonsil. In front the tonsil is in relation with the anterior pillar of the fauces, and therefore with the palato-glossus muscle; behind, with the posterior pillar, and accordingly with the palato-pharyngeus muscle.

Structure. In structure the tonsils are intermediate between mucous follicles and glands: they consist of an agglomeration of follicles, continuous with those at the base of the tongue. Groups of these follicles open into small cells or lacunæ, which again open upon the internal surface of the tonsil by the foramina already described. The mucous membrane covers the inner surface of the tonsil, and, penetrating through the foramina, lines the interior of all the cells.

The *arteries* are very large, considering the size of the organ. They are derived from the labial, the inferior pharyngeal, the lingual, and the superior and inferior palatine. The *veins* form a plexus round this organ, called the *tonsillar* plexus: it is a dependence of the pharyngeal plexus. The *lymphatic vessels* terminate in the glands found near the angle of the jaw; hence the inflammation or enlargement of those glands in consequence of inflammation of the tonsil. The lingual and glosso-pharyngeal *nerves* form a plexus outside the tonsil, which gives off some branches to it.

The Tongue.

The *tongue*, the principal organ of taste, is situated within the buccal cavity, and consequently at the commencement of the digestive passages (*b*, *fig.* 140.) behind the lips, which in many animals are organs of prehension; also behind the teeth, the organs of mastication, and below the organ of smell, which possesses the sense of taste in the lower tribes, and is necessary in all animals for the perception of flavours. It is a muscular organ, free and moveable above, before, and on the sides. It is retained in its position by ligaments which attach it to the os hyoides; and, by muscles connecting it to the same bone, to

* The existence of this aponeurosis explains why the tonsil always becomes enlarged internally, and also why abscesses of this part never open externally.

the styloid processes and to the lower jaw; so that it appears to me anatomically impossible for persons to have been destroyed by swallowing their tongues, as some historians have related. Nor do I believe, notwithstanding the authority of J. L. Petit, that division of the frænum in infants may be followed by a similar accident.

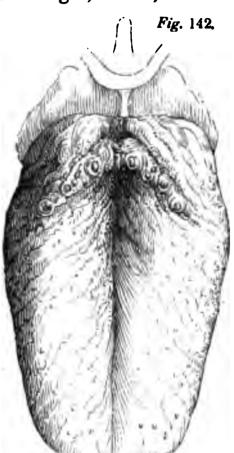
The *size* of the tongue, though variable in different individuals, is always proportional to the curve described by the lower jaw: it is not large enough to fill the buccal cavity completely when the jaws are closed. It has not been satisfactorily proved that too large a tongue is the cause of certain defects in speech. However, a natural size is not absolutely necessary for the exercise of its functions, for these are performed even when considerable portions have been removed from its apex and sides.

Direction. Its anterior portion is horizontal, behind, it slopes downwards and backwards, and curves abruptly, so as to become vertical and reach the os hyoides, which in some measure constitutes its base. This direction, which is maintained so long as the tongue is within the mouth, is somewhat altered when it is protruded, the tongue then becoming horizontal, and the os hyoides raised.

Figure. Examined without any anatomical preparation, the tongue appears of an oval figure, having its great end behind. Its form is determined, and as it were measured, by the parabolic curve of the lower jaw, by which it is circumscribed. When separated from the neighbouring parts it represents an ellipse, with its long diameter from before backwards. It is perfectly symmetrical, flattened above and below, narrow and thin in front, and increasing in thickness and in breadth from before backwards. Its figure, which has itself become a term of comparison, does not appear to be essential for the articulation of sounds, a function that would at first appear to be peculiarly connected with this form.

The tongue presents for our consideration an upper and a lower surface, two edges, a base, and an apex.

Fig. 142.



The upper surface or dorsum of the tongue. This is free in the whole of its extent, corresponds to the roof of the palate, and is divided into two lateral halves by a median furrow, which often limits the progress of disease. It is covered by innumerable eminences, which render it very rough; these should be distinguished into such as are perforated, viz. the glandular eminences, and such as are entire, and have no orifice, viz. the *papillæ* (*papilla*, a nipple).

The *perforated eminences*, or *lingual glands*, improperly classed among the papillæ, and known under different names, may be distinguished by their circular openings, which are perfectly visible to the naked eye; by their being situated only at the base of the tongue; by their rounded form, and their having no pedicle; by the arrangement of the mucous membrane, which passes over without adhering to them *; and lastly by dissection, which most distinctly reveals their glandular nature. These lingual glands, moreover, are not follicles, but true glandular organs, analogous to the labial and buccal glands. They form a V-shaped ridge, strongly marked in some subjects, and bounded in front by the ridge (*a a*, *fig.* 142.) of the same shape, formed by the caliciform papillæ.

* [*I. e.* without being closely united to their *outer* surface, as it is to that of the papillæ. The mucous membrane, as in all glands, is really prolonged into their interior.]

All the other eminences of the tongue are papillæ which we may describe as the *large* and the *small*.

The *large papillæ* are called *caliciform*: they are arranged in two lines (*a a*, *fig.* 142.), united like the limbs of a V, open in front. Their number varies from sixteen to twenty, some of which are placed irregularly. Haller has seen them forming two rows on each side. Their size is also variable, but they are larger than all the other papillæ. Each papilla forms a truncated and inverted cone, the base of which is free, and the truncated apex adherent, (papillæ truncatæ, *Haller*; papilles boutonnées ou à tete, *Boyer*). They are placed in a sort of calyx or cup, or surrounded by a circular trench: hence the name of papillæ circumvallatæ (papilles caliciformes, *Cuvier*). The border or rim of this cup is itself a circular papilla.*

At the angle of union of the two rows of these glands is a *blind opening* (*b*), which is frequently wanting, and generally known as the foramen cæcum of *Morgagni* (lacune de la langue, *Chaussier*). Several anatomists of the last century affirmed that certain supposed salivary ducts, which were afterwards shown to be merely veins, had their termination in this foramen; it is now generally considered to be a cul-de-sac for the reception of the secretion from several follicles; but it appears to me to be only the cavity of a calyx, the papilla corresponding to which is very imperfectly developed. When the papilla is more developed, or the calyx less deep than usual, the foramen cæcum is said to be wanting.

The small papillæ. These occupy all that part of the dorsal surface of the tongue, which is in front of the V-shaped ridge formed by the papillæ circumvallatæ; they present many varieties. Some of them are *conical*, others *filiform*; some are pointed like a reed, and others are *lenticular* or *fungiform*, that is, flattened at the top and supported by a narrow pedicle: but the conical or filiform are evidently the most numerous, for they occupy of themselves the anterior portion and the apex of the tongue, whilst all the other varieties are disseminated between them. They are directed obliquely backwards, so that by rubbing the tongue slightly from behind forwards, they may be brushed up, and their exact shape and length ascertained. This oblique direction is much more marked in the lower animals than in man.

The conical papillæ are sometimes arranged in regular or irregular lines, so as to give the tongue a fissured appearance. Sometimes even several papillæ are united in a line, so as to form a jagged ridge. We may add, that there is very great variety both in the shape and arrangement of the lingual papillæ.†

The *lower surface* of the *tongue* is free only in its anterior third, the muscles which connect the tongue to the neighbouring parts being attached to the posterior two thirds. On the free portion, which we shall alone notice here, is observed a median furrow, more distinct than that on the upper surface. At the posterior part of this furrow is a fold of mucous membrane, called the *frænum linguæ*, which is sometimes prolonged to the apex of the tongue, and prevents the movements of that organ, both in the act of sucking and during articulation: hence the necessity for the operation, known as the division of the frænum. On each side of this furrow are seen the ranine veins, on which the ancients performed venesection; also an antero-posterior projection formed by the lingual muscle.

* The want of an uniform nomenclature for the papillæ of the tongue has occasioned great obscurity. I do not know two authors who agree in this respect. M. Boyer calls the lingual glands, *papilles lenticulaires*; the caliciform papillæ, *papilles boutonnées ou à tête*; and applies the term *papilles coniques* to the papillæ generally known by that name. Gavard called the glands, *papilles muqueuses*; and the caliciform papillæ, *papilles fungiformes*. M. H. Cloquet appears to have confounded both the glands and the caliciform papillæ under the name of *papilles lenticulaires*; the *papilles fungiformes*, according to him, are irregularly disseminated over the edges and apex of the tongue. The use of the term conical papillæ, is the only point in which they are all agreed.

† [All these kinds of papillæ are extensions of the mucous membrane, and are therefore composed of similar elements. The papillæ vallatæ contain many loops of vessels, the papillæ conicæ in general only a few; all are abundantly supplied with nerves.]

The *edges* of the tongue are thick behind, and thinner towards the point. The papillæ are prolonged in a regular manner upon their upper half in a series of vertical and parallel lines.

The actual *base* is fixed to the os hyoides: the apparent base, which is seen at the back of the dorsal surface, presents three *glosso-epiglottid* folds, of which the median (above *b*, *fig.* 142.) is much larger than the other two.

The *apex* is situated immediately behind the incisor teeth; the median furrows of both surfaces are prolonged upon it.

Having thus examined the peculiarities offered by the external surface of the tongue without the aid of dissection, we shall now examine its structure.

Structure of the tongue. The tongue being the organ of one of the senses, and being also capable of various movements, we must examine its structure with reference to both these objects. But after the example of Haller *, we shall be principally occupied here with its structure as a moveable organ.

The tongue is essentially composed of muscular fibres, and in this respect the heart is the only organ which can be compared to it. Its framework consists of the os hyoïdes, of a median cartilaginous lamina, and of its papillary membrane.

Framework of the tongue. The os hyoides, already described (seen in *fig.* 143.), is truly the bone of the tongue: hence it has been called the lingual bone by some anatomists. In man it is not prolonged by a process into the substance of the tongue, as in the lower animals, but is united to it by the hyo-glossal membrane, which commences at the posterior lip of the body of this bone; and again, since the os hyoides is united to the thyroid cartilage (*t*) by ligaments, it follows that all the movements of this bone are communicated both to the tongue and to the larynx, between which parts it is situated. From the middle of this fibrous membrane the *median cartilaginous lamina* of the tongue, described by M. Blandin, proceeds. This lamina, which is perfectly distinct from the cartilage described by M. Baur in the dog and the wolf †, is situated in the median line; it is directed vertically, and gives attachment to some muscular fibres by its two lateral surfaces; its upper edge is thin, and reaches the middle of the dorsal region of the tongue; its lower edge is seen between the genio-hyo-glossi, where it is either free or covered by a few muscular fibres which interlace below it. It is thick behind, but thin in front, where its fibres have a number of intervals between them, like those in the septum of the corpora cavernosa penis.

I regard the *papillary membrane* as part of the framework of the tongue, on account of its density, which is so great, that it is with difficulty cut by the scalpel. Moreover, a great number of the muscular fibres terminate in it.

The Muscles of the Tongue.

These are either intrinsic or extrinsic.

The intrinsic muscles. The ancients regarded the tongue as a single muscle, the structure of which they did not attempt to unravel. Columbus was the first to consider this organ as composed of two juxtaposed muscles. If the texture of the tongue be examined by means of sections made in different directions, it will be found to be composed of an interlacement of muscular fibres, which will, indeed, appear to be inextricable. Among these different sections, I would principally call attention to a vertical section, made at right angles to the axis of the tongue. This section presents a pale muscular tissue in the centre, in which successive layers of vertical and transverse fibres may be distinguished. A soft fatty substance, the *lingual adipose tissue*, is interposed between these muscular fibres; it is analogous to the fat formed at

* Haller treats of the muscles of the tongue when describing the organ of voice (lib. ix. sect. ii. p. 421.), and of the papillary membrane with the organs of the senses (lib. xiii. sect. i. p. 99.).

† The cartilage described by Baur is a fibrous cord, subjacent to the mucous membrane, and occupying the median line on the lower surface of the tongue. It extends from the apex of the latter, where it is very well marked, to the base, where it terminates in a cellular raphé.

the base, or sometimes among the fibres of the ventricles of the heart; it increases in quantity towards the base of the tongue, but is entirely wanting at the apex. Around this central part of the tongue, which may with propriety be called, after M. Baur, the *lingual nucleus* (*noyau lingual*), we find a very thin layer of red fibres situated above, a somewhat thicker layer on each side, and a much thicker layer below; the lateral and inferior layers belong to the extrinsic muscles.

A *transverse vertical section* therefore demonstrates the presence of vertical and transverse fibres in the tongue: an *antero-posterior vertical section* shows that there are fibres running from one end of the organ to the other, and will also display the vertical fibres already mentioned. Thus, by means of simple sections, we can demonstrate the existence of *longitudinal* fibres running from the base to the apex of the tongue; of *vertical* fibres passing from the upper to the lower surface; and of *transverse* fibres extending from one side to the other: and other dissections will confirm this statement. Though Malpighi *, in a memoir of great interest, had very exactly described and figured the arrangement of the three orders of fibres in the tongue of the calf; though Steven proved their existence in the human tongue, and Bidloo had carried his observations still further; and although Massa had recommended that to facilitate this investigation the tongue should be previously boiled, or should be examined after putrefaction had commenced; still almost all anatomists, including Haller, neglected this subject, until MM. Baur, Gerdy, and Blandin directed attention to it almost at the same time. From the examination of the boiled tongues of the ox, the sheep, and man, I have observed the following facts: —

1. Under the papillary membrane, which, as I have said before, has almost the density of cartilage, there is a series of fibres running from before backwards. These fibres appear to rise in succession from the papillary membrane, and form a layer, which is thicker in front, where the fibres are collected into a small space, than it is behind, where they are scattered and pale. In the ox they traverse the yellowish glandular-looking substance found at the base of the tongue. This thin layer is described by Malpighi, and has been called the superior or *superficial* lingualis muscle: —

2. On the lower surface of the tongue, between the genio-hyo-glossus and the hyo-glossus, we find a longitudinal bundle, reaching from the base to the apex. This thick bundle was first described by Douglas under the name of the *lingualis muscle*; it might be called the *inferior lingualis*. The *lingual* muscle of authors generally† is a small muscular fasciculus, situated on the lower surface of the tongue, between the stylo-glossus (*u*, *fig.* 143.) and the genio-hyo-glossus (*a*). It arises from the base of the tongue, in an indistinct manner, amidst an intricate mass of muscular fibres; from thence it passes forwards, and terminates at the apex of the tongue, where it unites with the fibres of the stylo-glossus. It shortens the tongue, and depresses its point.

3. On either side of the tongue we find two layers of oblique and very thin fibres, crossing each other. The superficial layer consists of fibres passing forwards and downwards, the deep layer of fibres running obliquely forwards and upwards. These two layers can only be seen towards the base. They are more easily shown in the ox than in man. We also find along each side some antero-posterior fibres, continuous both with the stylo-glossus and the palato-glossus.

4. Lastly, the dissection of the lingual nucleus of a boiled tongue enables us most distinctly to separate the vertical and transverse fibres already noticed as being seen in the different sections of the tongue. The transverse fibres form a slight concavity above; the vertical fibres converge a little from above down-

* It is not unworthy of notice, that Malpighi commenced upon the tongue that series of researches into the structure of organs, which has made him as it were the founder of textural anatomy.

† [From this statement Albinus must be excepted; the *lingualis* of that anatomist corresponds exactly with the muscle described by Douglas.]

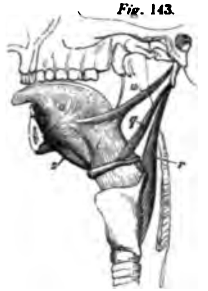
wards. In the substance of the lingual nucleus, near the base of the tongue, a soft, liquid, adipose matter is interposed between the muscular fibres.

The *extrinsic muscles*. The extrinsic muscles are three on each side, viz. the stylo-glossus, the hyo-glossus, and the genio-hyo-glossus.

The Stylo-Glossus.

The *stylo-glossus* (*u*, *figs.* 114. 143. 146.) is a small, slender muscle, cylindrical above, thin, triangular, and bifid below. It *arises* from the styloid process by some tendinous fibres surrounding the lower half of that process, and slightly also from the stylo-maxillary ligament. The fleshy fibres proceeding from these points form a rounded fasciculus, which passes downwards, inwards, and forwards. At the margin of the tongue, opposite the anterior pillar of the fauces, the muscle becomes flattened, expanded, and triangular, and divides into two parts,—one external, which runs along the corresponding margin of the tongue, from the base to the apex; the other internal, which passes between the two portions of the hyo-glossus, assumes a transverse direction, and is blended with the transverse fibres of the tongue.

Fig. 143.



Relations. On the outside it is in relation, successively, with the parotid gland, the internal pterygoid muscle, the sublingual gland, the lingual branch of the fifth nerve, and the mucous membrane of the tongue. On the inside it has relations with the stylo-hyoid ligament, the tonsil, the superior constrictor of the pharynx, and the hyo-glossus muscle.

Action. The stylo-glossus draws the corresponding edge of the tongue, and consequently the entire organ, upwards, and to its own side. When the two stylo-glossi act together, the tongue is increased in breadth, and carried upwards and backwards: it therefore assists in retraction of the tongue.

The Hyo-glossus.

This is a thin quadrilateral muscle (*t*, *figs.* 113, 114. 146.) *arising* from the os hyoides by two very distinct origins,—one from the body of the bone, near the great cornu; the other from the whole extent of the anterior border of the great cornu; and also from its point.

From this double origin the fleshy fibres pass upwards parallel to each other, forming a quadrilateral muscle, which expands a little in order to terminate upon the sides of the tongue, between the stylo-glossus and the lingualis. There is an evident continuity between this muscle and the vertical fasciculi of the tongue.

The *direction* of this muscle varies according to the positions of the tongue. It is vertical when the organ is contained in the buccal cavity, and is directed obliquely upwards and forwards when the tongue is protruded.

The hyo-glossus is almost always divided into two portions corresponding to its double origin, which are separated below by a cellular interval, and above by the posterior fasciculus of the stylo-glossus. Albinus described them as two distinct muscles; the portion arising from the body of the os hyoides, as the *basio-glossus;* and under the name of the *cerato-glossus*, the portion arising from the great cornu. He also admitted a third portion, under the name of the *chondro-glossus*, described as proceeding from the small cornu. Haller, who considered this latter fasciculus a distinct muscle, states that he has always been able to find it.

Relations. On the outside it is in relation with the stylo-glossus, the mylo-hyoideus, the digastricus, the sublingual gland, the hypo-glossal nerve,

and lingual branch of the fifth. On the inside, it corresponds to the lingual artery, which never passes between the two portions of the muscle, to the genio-hyo-glossus, and to the middle constrictor of the pharynx.

Action. It depresses the corresponding edge of the tongue, and draws it towards the os hyoides. When the tongue has been protruded from the mouth, it assists in drawing it backwards. When the two muscles act together, the tongue is depressed and contracted in its transverse diameter.

The Genio-hyo-glossus.

This is the largest of the extrinsic muscles of the tongue: it is thick, triangular, and as it were radiated (*a, fig.* 143.). It *arises* from the superior genial process of the inferior maxilla by a sort of tendinous tuft, from which the fleshy fibres immediately proceed as from a centre, radiating backwards in different directions. The posterior fibres are attached to the os hyoides, either directly or through the medium of a membrane. They constitute the superior *genio-hyoideus* of Ferrein. The more anterior fibres expand upon the sides of the pharynx, occupy the interval between the os hyoides and the stylo-glossus, and immediately cover the corresponding portion of the pharynx, or rather the amygdaloid excavation. These fibres, which are very distinct (I was acquainted with them before I was aware that they had been described by others), constitute the *genio-pharyngiens* of Winslow. The fibres, which are next in order, proceeding forwards, all belong to the tongue, and traverse the whole length of that organ. The most anterior fibres, which are the shortest of all, having reached the lower surface of the tongue, curve forwards, and terminate near its point. All the others pass perpendicularly upwards and turn a little outwards, so as to terminate in the papillary mucous membrane at the side of the median line.

Relations. On the *inside* it corresponds to its fellow, being separated from it by cellular tissue frequently loaded with fat. The two muscles are perfectly distinct, and separable until they enter the substance of the tongue, beyond which point they cannot be separated from each other. On the *outside* it is in relation with the sublingual gland, the mylo-hyoideus, hyo-glossus, stylo-glossus, and lingualis muscle. The hypo-glossal nerve perforates this muscle between its genio-pharyngeal and lingual portions. Its *lower margin* corresponds to the genio-hyoideus, from which it is separated by a very delicate layer of cellular tissue. Its *upper margin* is subjacent to the mucous membrane, of which it occasions a prominence on each side of the frænum.

Action. By its hyoid fibres it raises the os hyoides and carries it forwards; by its pharyngeal fibres it draws the pharynx forwards and compresses its sides; by its posterior lingual fibres, as well as the hyoid, it carries the base of the tongue, and consequently the whole organ forwards. This is the muscle by which we are enabled to protrude the tongue from the mouth. By means of its anterior or reflected fibres, the tongue, when protruded, is drawn back into the mouth; lastly, by its median lingual fibres, the tongue is made into a groove; when one muscle acts alone, it is protruded to the opposite side.

Such, including the palato-glossus, already described, are the extrinsic muscles of the tongue: I shall not include among them the *mylo-glossus* of the older anatomists, and described also by Heister and Winslow, because it appears to be nothing more than that portion of the superior constrictor of the pharynx, which is inserted into the mylo-hyoid ridge; nor yet the *glosso-epiglottideus*, a very large muscle existing in the lower animals, which has been described by Albinus in the human subject as a dependence of the genio-hyo-glossus. After the most careful examinations I have never been able to meet with it.

Vessels, nerves, and cellular tissue. The cellular tissue of the tongue receives arteries and veins, and from it issue both veins and lymphatics.

The *arteries* consist of the proper lingual, which are very large in comparison to the size of the organ, the palatine, and the inferior pharyngeal.

The *veins* form two sets, as in the limbs, and for the same reason—a superficial set independent of the arteries, and a deep set accompanying those vessels.

The *lymphatics* enter the deep lymphatic glands of the supra-hyoid region.

The *nerves* are very large, and are derived from three sources, viz. from the ninth pair or hypo-glossal; from the lingual branch of the fifth pair; and from the glosso-pharyngeal division of the eighth pair.*

The *cellular tissue* of the tongue is partly serous and partly adipose; the serous portion is chiefly situated in front, the other is more abundant behind.

The tegumentary membrane and glands. The *tegumentary membrane* of the tongue is a continuation of the mucous membrane of the mouth. It is thin and slightly adherent in almost all its non-papillary portion, and becomes very thick and strongly adherent wherever the papillæ exist. The edges of the tongue are occupied by numerous small glands, continuous with the sublingual glands, and opening upon the lower wall of the mouth by small excretory ducts.

Developement. The tongue is visible in the youngest embryos. Its early developement has reference to its functions, for it is an essential agent in suction, and is consequently brought into use immediately after birth. The tongue is not double or bifid at first; in the earliest embryos it presents the appearance of a single tubercle.

Uses of the tongue. The tongue has two very distinct uses. It is the organ of taste, and it is also a moveable organ. In this place we shall consider it in the latter capacity only. The movements of the tongue are concerned in the prehension of food, in suction, in mastication, in tasting, in deglutition, in articulation, and in playing upon wind-instruments.

In order to fulfil such a variety of uses, it is organised so as to be capable of moving in every direction. Its movements are either *extrinsic* or *intrinsic*. The extrinsic movements, or those of the whole tongue, may be ascertained from our knowledge of the single or combined actions of its extrinsic muscles. Thus it may be protruded from the mouth, drawn back into that cavity, inclined to the right or to the left side, directed upwards or downwards, or carried into any intermediate position. In its intrinsic movements it may be contracted transversely by the transverse fibres, diminished in length by its longitudinal fibres, and contracted vertically, and rendered concave by its vertical fibres; lastly, its apex can be carried upwards by the superior, and downwards by the inferior longitudinal fibres.

By far the most varied, precise, and rapid motions of this organ are required in the articulation of sounds, in which it is one of the chief agents. In consequence of this use, which is by no means the result of a special conformation (for by constant practice, animals, whose tongues are very different from ours, may be taught to articulate), the tongue is associated with, and becomes one of the principal instruments of the mind. It is the organ by which thought is most commonly expressed. This use is peculiar to man.

* The ninth nerve is distributed to the muscles, the lingual nerve to the mucous membrane of the anterior part and sides, and the glosso-pharyngeal to that of the base of the tongue. (See Organ of Taste.)

I have lately seen a considerable branch of the facial nerve terminating in the tongue; it was given off from the facial nerve at its exit from the stylo-mastoid foramen, crossed obliquely in front of the styloid process with which it was in contact, passed in front of the stylo-pharyngeus muscle externally to the tonsil, and parallel to the glosso-pharyngeal nerve, which was situated behind it, communicated with that nerve by several arches, and divided into two branches at the base of the tongue, one of which ran along the edge of that organ, and the other anastomosed by a loop with the glosso-pharyngeal: from this loop some filaments passed off, to be distributed in the usual manner.

The opposite side did not exhibit a corresponding arrangement.

The Salivary Glands.

esides the labial, buccal, and palatine glands found in the cavity of the mouth, :h by most anatomists have been confounded with the follicles or muci-us crypts, there exists around this cavity a particular glandular apparatus, ing a sort of chain or collar, symmetrically extended along the rami and r of the lower jaw. This chain is interrupted so as to form six glandular es, three on each side, named from their situation the *parotid*, *sub-maxillary*, *sub-lingual glands.**

The Parotid Gland.

he *parotid gland* (*p*, *fig.* 144.), so called from being situated below and in front of the external auditory meatus (παρὰ, near, οὖς, ὠτὸς, the ear), fills the parotid excavation. It is bounded in front by the posterior edge of the ramus of the lower jaw; behind, by the external auditory meatus and the mastoid process; above, by the zygomatic arch; below, by the angle of the lower jaw; and on the inside, by the styloid process and the muscles which proceed from it. This gland has given its name to the region occupied by it.

Fig. 144.

It is the largest of all the salivary glands, and even exceeds all the rest put together. Its form is irregular, and is determined by that of the surrounding parts, upon which it is moulded like a piece of soft wax. Its superficial portion is broad, but it suddenly becomes contracted when it dips behind the ramus of the jaw.

ı order to obtain a good idea of the size and shape of this gland, it must be ›ved entire from the irregular mould in which it is lodged. It has been pared to a pyramid, of which the base is directed outwards, and the apex ırds.

elations. Its *external surface*, or base, is broad, oblong from above down-ls, irregularly quadrilateral, and lobulated at the edges; it is subcutaneous, g separated from the skin, however, by the parotid fascia and the risorius antorini, when that muscle exists.†

s *anterior surface* is grooved so as to embrace the posterior edge of the ıs of the lower jaw. A bursa, or some loose cellular tissue facilitates the ements of these parts. This surface is also in relation with the internal ygoid muscle, the stylo-maxillary ligament, and the masseter muscle, on external surface of which it is prolonged to a greater or less extent (see 144.) in different individuals, and is separated from it anteriorly by the ifications of the facial nerve, by some loose cellular tissue, and by the sverse artery of the face.

s *posterior surface* is in relation with the cartilaginous portion of the ex-al auditory canal, being moulded upon its convexity, and adhering to it ery dense cellular tissue: it corresponds also to the mastoid process, the ıo-cleido-mastoid and digastric muscles, and indirectly to the transverse ess of the atlas. This surface is extremely irregular, adheres by means

The continuity of this glandular chain, admitted by some anatomists, is only apparent. A s septum always intervenes between the sub-maxillary and the parotid glands.

n a female in whom I dissected the parotid gland, the risorius arose from the superior ircular line of the occipital bone by two distinct fasciculi, which, passing downwards and rds, united opposite the apex of the mastoid process, and then proceeding horizontally, ded upon the parotid gland. Some of the fibres reached the commissure of the lips, but reater number were lost upon the parotid fascia.

of dense cellular tissue, and is dissected off with great difficulty in an attempt to remove the entire gland.

On *the inside* it is reduced to a mere border, which corresponds to the styloid process, and the muscles and ligament connected with it. It sends off a considerable prolongation into the space which separates the styloid process and its muscles from the internal pterygoid; but the most important relation of this border is with the external carotid artery, for which it furnishes a groove and sometimes even a complete canal.

Its *upper extremity* corresponds to the zygomatic arch and the temporo-maxillary articulation.

Its *lower extremity* fills up the interval between the angle of the jaw and the sterno-mastoid, and is separated from the sub-maxillary gland (*m*) by a very thick fibrous septum.

Besides the relations already indicated, the parotid has others with the vessels and nerves which traverse it at different depths: these may be called its *intrinsic* or *deep* relations. Thus the external carotid artery almost always perforates the gland near its inner side; the temporal artery (see *fig.* 144.), the transversalis faciei, and the anterior auricular, which commence in the substance of the gland, also traverse it in various directions. We also find within it the temporal vein, which is a communicating branch between the external and internal jugulars; the trunk of the facial nerve is at first placed behind the gland, then penetrates it, and divides into two or three branches, which again subdivide and traverse it in all directions. The auricular nerve, a branch of the cervical plexus, also passes through it very superficially.* The parotid gland, by a remarkable exception, always contains in its substance, a little below the surface, several lymphatic glands, which may be readily distinguished by their red colour from the proper tissue of the gland. It may be imagined that a morbid developement of these glands may have often been mistaken for disease of the parotid itself.

Structure. A thick fibrous membrane covers the parotid glands, and sends prolongations into it which divide it into lobes, and these again into glandular lobules. The actual structure of the gland, therefore, depends upon the nature of these lobules; and without entering into details which belong more properly to general anatomy, it may be stated that it has been shown, by the aid of the simple microscope, that each lobule is a porous spongy body, something like the pith of the rush, and provided with afferent vessels, viz. the *arteries*; and efferent vessels, *i. e.* the *veins* and *excretory ducts.*† The relations of the nerves and lymphatic vessels with these granules have not been accurately determined.

The parotid *arteries* are very numerous: some of them arise directly from the external carotid; others from its branches, more particularly from the superficial temporal, the transversalis faciei, and the anterior and posterior auricular.

The *veins* have similar names, and follow the same direction as the arteries. There is a parotid venous plexus.

Fig. 145.

Magnified fifty times.

* These relations prove the almost absolute impossibility of extirpating this gland by a cutting instrument, and of compression after Desault's method, for the cure of salivary fistulæ. Compression, which is extremely painful on account of the number of nerves passing through it, can only affect its superficial portion.

† [Weber has succeeded in distending with mercury the ducts (*d*, *fig.* 145.) of the parotid gland in the infant, and has shown that they terminate in closed vesicular extremities (*c*), about $\frac{1}{1200}$th of an inch in diameter, three times that of the capillary vessels ramifying upon them. See *Müller's Physiology*, translated by Baly, p. 447., and *Müller on the Glands*, translated by Solly, p. 69. — (Tr.)

In the early embryo of the sheep, this gland consists of a canal which opens into the mouth by one extremity, but is closed at the other, and has numerous short hollow branches projecting from it into a granular blastema; as developement advances, the blastema is absorbed, and the ramified canal, increasing in length, becomes still more ramified, so as to form the ducts with their closed vesicular terminations.]

The *lymphatic vessels* are little known: they terminate partly in the glands at the angle of the jaw, and partly in those which lie in front of the auditory meatus. I have already said that one or more lymphatic glands are always situated in the parotid gland, a few lines below its surface.

The *nerves* are derived from the anterior auricular (a branch of the cervical plexus) and from the facial nerve: they seem to be lost in the substance of the gland.

The parotid duct. A small excretory duct (resulting from the union of its terminating vesicles) proceeds from each lobule, and unites almost immediately, at a very acute angle, with the ducts of the adjacent lobules. From the successive union of all these ducts a single canal results, which emerges from about the middle of the anterior margin of the gland: this is the *parotid duct* (*s*, *fig.* 144.), called also the *duct of Steno*, although it had been previously described by Casserius. It passes horizontally forwards, about five or six lines beneath the zygomatic arch, across the masseter, and at right angles to its fibres. At the anterior border of the masseter it changes its direction, curves in front of a mass of fat situated there, dips perpendicularly into the fat of the cheek, perforates the buccinator in the same direction, and glides obliquely, for the space of several lines, between that muscle and the mucous membrane of the mouth, which it pierces opposite the interval between the first and the second upper great molar teeth, almost on a level with the middle of their crown.

The mode in which the Stenonian duct opens into the buccal cavity does not appear to me to have been sufficiently well understood. It exactly resembles the manner in which the ureters enter the bladder. Thus it glides obliquely for a certain distance beneath the mucous membrane, a fact that may be easily determined by perforating the cheek at the point where the duct passes through the buccinator, and then measuring the interval between this perforation and the buccal orifice of the canal: this interval varies from two to three lines in extent. Again, the buccal orifice is oblique, like the vesical opening of the ureter, so that it is extremely easy to pass a fine probe into it.

The duct of Steno is often accompanied by an *accessory gland** (glandula socia parotidis, see *fig.* 144.) situated between it and the zygomatic arch. The duct of this little gland opens into the main canal. I have seen two small accessory glands situated above the canal, one at the middle and the other at the anterior part of the masseter. Lastly, as the parotid duct is passing through the buccinator, it is surrounded by a series of glands continuous with those of the cheeks, called *molar glands*, the ducts of some of which appear to open into the canal, and those of others directly into the mouth. Although it is not flexuous, the canal when separated from the surrounding parts will be found much longer than it appears at first sight.

Relations. The Stenonian duct is subcutaneous and superficial where it passes over the masseter; it is protected by a large quantity of fat, and in front of the masseter by the zygomaticus major. A considerable branch of the facial nerve, and some arteries derived from the transversalis faciei, run along this canal.

Structure. An exaggerated idea is generally entertained of the thickness of the duct of Steno; it is only thick at its anterior part, where it is strengthened by an expansion of the aponeurosis of the buccinator muscle. When freed from the surrounding fat it is not thicker than most other ducts, the ureters for example. The notion that it is inextensible is also incorrect. It is true, however, that the diameter of its canal is not in proportion to the size of the gland. It is formed by two membranes,—one external, the nature of which is not well known; the other internal, consisting of a prolongation of the mucous membrane of the mouth. Its arteries and veins are very large.

* Desault found this gland very large in a subject where the corresponding parotid was atrophied.

The Sub-maxillary Gland.

The sub-maxillary gland (*m*, *fig.* 144.) is situated in the supra-hyoid region, and partly behind the body of the lower jaw: it is bounded by the reflected tendon of the digastricus, below which it almost always projects.

Size and figure. It is much smaller than the parotid, but larger than the sub-lingual. It is oblong from before backwards, elliptical, irregular, and divided into two or three lobes by some deep fissures.

Relations. On the *outside* and *below* it corresponds to a depression on the inferior maxillary bone, in which it is completely lodged when the jaw is depressed. When, on the other hand, the head is bent backwards upon the neck, the gland appears almost entirely in the supra-hyoid region, and is in relation with the platysma, being separated from it by the cervical fascia, to which it is united by cellular tissue of so loose a texture, that it may be called a synovial bursa. This surface of the gland is also in relation with the internal pterygoid muscle and the numerous lymphatic glands situated along the base of the jaw. On the *inside* and *above*, it corresponds to the digastric, mylo-hyoid, and hyo-glossus muscles, and to the hypo-glossal and lingual nerves.

The sub-maxillary gland almost always forms a prolongation of variable size and shape above the mylo-hyoideus. Sometimes the lobules of which it is composed are situated in lines, so as to appear like the Whartonian duct, or rather a second canal running parallel to it Most commonly this prolongation is of considerable size and irregular, and forms, as it were, a second sub-maxillary gland.

The most important relation of the gland is to the facial artery (*a*), which runs in a groove on its posterior border, and upon the contiguous part of its external surface. Sometimes this groove is prolonged forwards, and divides the gland into two unequal parts. We cannot avoid seeing the great analogy between this arrangement and that of the external carotid artery, with regard to the parotid gland.

Structure. This is identical with that of the parotid. Its investing fibrous membrane is weaker, and still more difficult of demonstration. The *arteries* are numerous, and arise from the facial and the lingual. The *veins* correspond to them. The *lymphatic vessels* are little known, and enter the neighbouring glands. The *nerves* are derived from the lingual and the myloid branch of the dental. I should remark that all the nerves proceeding from the submaxillary ganglion are destined for this gland.

The *excretory duct* of the sub-maxillary gland is called the *Whartonian duct*, although it was really discovered by Van Horne. It is formed by the successive union of all the small ducts proceeding from the lobules; it leaves the gland at the upper bifurcation of its anterior extremity, and consequently above the mylo-hyoideus, and is directed obliquely upwards and inwards, parallel to to the great hypo-glossal and lingual nerves. It is at first placed between the mylo-hyoid and hyo-glossus muscles, and then glides between the genio-hyo-glossus and the sub-lingual gland, to the inner surface of which it is attached.* I have never succeeded in determining whether it receives any excretory duct or ducts from this gland. Having reached the side of the frænum linguæ, the duct, which is sub-mucous in the whole of the portion corresponding to the sub-lingual gland, changes its direction, passes forwards, and opens by an extremely narrow orifice upon the summit of a prominent and moveable papilla found behind the incisor teeth. This orifice, which can scarcely be seen by the naked eye, was found to admit a hog's bristle in a particular case

* [See *fig.* 146., in which the gland itself (*m*) hangs down, resting upon the hyo-glossus; the digastric and mylo-hyoid muscles and half the lower jaw have been removed.]

presented to the Anatomical Society by M. Robert.* Bordeu has correctly described the appearance of this orifice by the term *ostiolum umbilicale*.

The duct of Wharton is remarkable for the thinness of its coats, which are not thicker than those of a vein; for its great caliber, which exceeds that of Steno's duct; for the extensibility of its coats, the canal sometimes acquiring an enormous size; and lastly, for its proximity to the mucous membrane of the mouth, which causes it, when much dilated, to project into the buccal cavity.

The Sub-lingual Gland.

The *sub-lingual gland*) *l*, *fig.* 146.), which may be regarded as an agglomeration of smaller glands analogous to those of the lips and palate, is situated in the sub-lingual fossa of the lower jaw, at the side of the symphysis menti: it is much smaller than the preceding gland, with which it is sometimes continuous. Its shape is oblong, like that of an olive flattened at the sides. The following are its relations:—It is subjacent to the mucous membrane, beneath which its upper edge forms a prominent ridge, running from before backwards along the sides of the frænum; its lower edge rests upon the mylo-hyoid muscle; its external surface corresponds, partly to the mucous membrane and partly to the sub-lingual fossa; its internal surface is in relation with the mucous membrane, with the genio-hyo-glossus (from which it is separated by the lingual nerve), with the Whartonian duct (which we have seen closely adheres to it), and with the ranine vein. Its anterior extremity touches the gland of the opposite side. Its posterior extremity and its lower edge are embraced by the lingual nerve, which gives numerous filaments to it. A small glandular prolongation also proceeds from its posterior extremity, and runs along the edge of the tongue.

Fig. 146.

Structure. Precisely similar to that of the other salivary glands. Its arteries arise from the sub-mental and sub-lingual. Its veins bear the same name. Its nerves are numerous, and are derived from the lingual.

Its *excretory ducts*, called also the *ducts of Rivinus* from their discoverer, are seven or eight in number. They open along the sub-lingual crest: their orifices may be shown by placing a coloured fluid in the mouth. Most anatomists state, that several of the ducts of this gland open into the Whartonian duct.

General characters of the salivary glands. The salivary glands present the following general characters:—

1. They are situated around the lower jaw, extending along its body and rami, from the condyles to the symphysis; they are in relation on the one hand with the maxillary bone, and on the other with numerous muscles, so that they are subjected to considerable compression during the movements of the lower jaw. 2. They all have direct relations with large arteries, which communicate their pulsations to them. 3. They receive vessels from a great number of points, and the vessels themselves are very numerous. 4. They are penetrated by many of the cerebro-spinal nerves, of which some only pass through, but a certain number terminate in them. 5. In structure they resemble the pancreas and the lachrymal glands; they have no special fibrous investment to isolate them completely from the surrounding parts; they have no precise form, and they are subdivided into lobes and lobules. 6. Their

* This was observed in a shoemaker; the bristle had become the nucleus of a salivary calculus.

excretory ducts pour their secretion into the mouth, *i. e.* the parotids between the cheeks and the teeth, the sub-maxillary and the sub-lingual glands behind the lower incisors on each side of the apex of the tongue. This distribution of the means of insalivation between the two cavities into which the mouth is divided, deserves the attention of physiologists.

The Buccal Mucous Membrane.

The buccal mucous membrane is continuous with the skin at the free edges of the lips; it lines their posterior surface, and is reflected from them upon each of the maxillary bones forming a cul-de-sac or trench, and in the median line a small fold called the frænum of the lips. About a line and a half, or two lines, from the free border of the lips, it changes its character and constitutes the gums, which are reflected upon themselves so as to become continuous with the fibro-mucous membrane, called the alveolo-dental periosteum.

In the lower jaw the mucous membrane passes from the alveolar border to the lower wall of the mouth, and from it to the under surface of the tongue. At the point of reflection in the median line, it forms the frænum linguæ. From the under surface of the tongue, the mucous membrane passes over its edges and upper surface, where it presents the peculiarities already described; and in being reflected from the base of the tongue to the epiglottis it forms three folds, the glosso-epiglottid, so as to become continuous on the one hand with the mucous membrane of the larynx, and on the other with that of the pharynx.

In the *upper jaw* it is extended from the upper alveolar border upon the roof of the palate, passing over the anterior and posterior palatine canals, which it closes but does not enter. From the roof of the palate it passes upon the velum, and is continuous with the nasal mucous membrane at its free edge. On the sides it forms two large folds for the pillars of the fauces, lines the amygdaloid excavation, covers the tonsil, and becomes continuous with the mucous membrane of the base of the tongue and of the pharynx.

At the sides of the buccal cavity the mucous membrane is reflected from both the alveolar borders upon the inner surface of the cheeks, and thus forms two trenches. At the anterior edge of the ramus of the jaw, behind the molar teeth, it is elevated by a salivary gland which marks the limit between the cheeks and the pillars of the fauces. Inside this prominence it forms a cul-de-sac.

The buccal mucous membrane sends off prolongations into the numerous canals which open into the mouth. Thus on the floor of the mouth there are two for the Whartonian ducts and several for the small ducts of the sub-lingual glands. Two others are seen on the inner sides of the cheeks for the ducts of Steno; and it is also clear that it must penetrate into the thousands of other orifices with which the mouth is studded (those of the buccal, labial, palatine, and other glands). But in all these prolongations its structure is modified, and it becomes exceedingly thin. It has been proved that it lines not only the larger ducts, but even their minutest subdivisions. Thus there is a kind of parotitis which consists in inflammation of the lining membrane of the excretory ducts of that gland; and then all the canals are filled with muco-puriform secretion, which escapes by the buccal orifice when the gland is compressed. The numerous openings on the surface of the tonsil are formed by the prolongations of this membrane into the cavities situated in its interior.

Although the different parts of the buccal mucous membrane are continuous, they do not all possess the same characters. Compare for instance, in regard to their density, thickness, and closeness of adhesion to the subjacent tissues, the mucous membrane of the gums and palate with that of the lips and cheeks, or the membrane covering the lower with that upon the upper surface of the tongue, or the mucous membrane of the free edge of the velum palati with that of the arches and the amygdaloid excavation.

The two principal characters of the buccal mucous membrane are the following:—1. The presence of an epidermis or *epithelium** (as it is called in mucous membranes). This can be distinctly demonstrated by maceration, or by the action of boiling water or some acid; by any of these means a pellicle is raised having all the characters of an epidermis. It is very thick upon the gums, the roof of the palate, and upon the tongue, where it forms a horny sheath to each papilla. To the existence of this membrane, and of the fluid with which it is constantly kept moist, we must attribute the possibility of applying, or rather running, a red hot iron over the surface of the tongue without burning the part. 2. The multiplicity of small subjacent glands so near to each other in some parts as to form a continuous layer. These glands should be carefully distinguished from the muciparous follicles or crypts, with which many modern anatomists have commonly confounded them. To these two characteristics a third may be added, peculiar to some portions of the buccal mucous membrane, viz. that it is supported by a very dense fibrous tissue, with which it is completely united. This fibrous layer is perfectly distinct from the periosteum, and from its presence the mucous membrane should be arranged among the *fibro-mucous membranes.*

The Pharynx.

The *pharynx* (φάρυγξ, the throat†; 1, 2, 3, *fig.* 140.), long confounded with the œsophagus under the common name of *gula* or *œsophagus*, is a muscular and membranous semi-canal, perfectly symmetrical, and situated in the median line: it is a sort of vestibule, common to the digestive and the respiratory passages, intermediate between the buccal and nasal cavities on the one hand, and between the œsophagus and larynx on the other. It is situated deeply in front of the vertebral column, extending from the basilar process of the occipital bone to opposite the fourth or fifth cervical vertebra and the cricoid cartilage. It therefore corresponds to the parotid, and partly to the supra-hyoid regions.

Its *dimensions* deserve particular attention. It is smaller than the mouth, but larger than the œsophagus, which, compared to it, resembles the tube of a funnel. Hence it follows, that foreign bodies which have been able to pass along the mouth and pharynx, may be arrested in the œsophagus.

In *length* it is from 4 to 4½ inches, which may be increased to 5½ or even 6½ by distension, and reduced to 2½ by the greatest possible contraction, which is limited only by the contact of the base of the tongue with the velum palati rendered horizontal. The length of the pharynx, therefore, may be made to vary about 4 inches.

The pharynx undergoes these extreme variations both in deglutition and in modulating the voice; in effecting which latter purpose it acts in the same way as the tube of a clarionet or flute. Thus considered, the entire length of the pharynx may be divided into three parts—a nasal (1, *fig.* 140.), a buccal or guttural (2), and a laryngeal (3) portion. It may be easily seen that the variations in length affect almost exclusively the buccal portion, into which the air is received after escaping from the larynx. Now these variations in the length of the pharynx have the same influence over the compass of the human voice, as the differences in the lengths of the tubes of wind-instruments have upon the sounds produced by them.

The *breadth* of the upper or nasal portion of the pharynx is measured by the interval between the posterior margins of the internal pterygoid plates: it is about one inch, and is invariable. In the buccal portion the same diameter is measured by the interval between the posterior extremities of the alveolar borders, and is about two inches: it may be diminished to one inch by the

* [The existence of an epithelium is *common* to all mucous membranes; that of the buccal cavity is of the *squamous* variety.]

† The term pharynx had no well defined meaning among the ancients: they sometimes used it to designate the pharynx, properly so called; sometimes the larynx.

contraction of the constrictor muscles. The breadth of the laryngeal portion is measured, first, by the interval between the summits of the great cornua of the os hyoides, where it is about one inch and near two lines; then by the interval between the superior cornua of the thyroid cartilage, which is an inch and two or three lines; and lastly by the interval between the inferior cornua of the same cartilage, about eleven or twelve lines. The contraction of this laryngeal portion may be carried to complete obliteration of the cavity.

Both the buccal and laryngeal portions, therefore, are capable of contraction, and this always takes place in deglutition, in order to force down and compress the alimentary mass. Contraction of the buccal portion also takes place in the modulation of sounds: it exerts the same influence over the compass of the human voice as the contraction of the tubes of the flute or clarionet does over the notes of those instruments.

The *antero-posterior dimensions of the pharynx* are not subject to the same variations as the transverse and vertical, on account of the presence of the vertebral column. Its enlargement in this direction is produced during that period in the act of deglutition when the larynx and os hyoides are carried forwards and upwards, and its diminution at the time when the same parts are carried upwards and backwards. The antero-posterior diameter of the pharynx depends upon the length of the basilar process of the occipital bone.

Figure. The pharynx does not form a complete cavity with distinct and separate walls, but rather half or two thirds of a canal, which is completed in part by several organs otherwise not belonging to it. Moreover the pharynx, from its commencement down to the larynx, is habitually open, and in a state of tension; its walls are never in apposition—an important circumstance in reference to the continual passage of air through its nasal and buccal portions. This tension depends on its attachment to the basilar process, and to the fixed points at its sides, and also upon the tendinous structure of its upper portion. Opposite the larynx, the tension ceases to exist.

The pharynx, as well as all other hollow organs, presents an external and an internal surface.

The external surface. This is in relation *behind* by a plane surface with the vertebral column (see *fig.* 140.), from which it is separated by the long muscles of the neck and the anterior recti of the head. It glides by means of some very loose cellular tissue upon the fascia covering the muscles of that region; and when from the effect of inflammation this cellular tissue becomes dense, the movements of deglutition cannot be performed, and dysphagia is the result. The relation of the pharynx to the vertebral column accounts for congestive abscesses of the neck sometimes opening into the pharynx.

At the sides the pharynx is separated from the internal pterygoid muscle by a triangular space, broad below and narrow above, occupied by the internal carotid artery, the internal jugular vein, and the pneumogastric, glosso-pharyngeal, hypo-glossal, and spinal accessory nerves, all being surrounded by very loose cellular tissue. The sides of the pharynx are also indirectly in relation with the parotid gland and the styloid muscles. Lower down, the pharynx corresponds to a great number of lymphatic glands, and to the external carotid artery and its branches.

The internal surface. In order to examine this surface it is necessary to open the pharynx from behind by a vertical incision. We shall then perceive that this structure only exists behind and at the sides, but that *in front* it presents a great number of openings (see *figs.* 140, 141.), the arrangement of which is of great interest.

Proceeding from above downwards, we find 1. the two posterior openings of the nasal fossæ (1), quadrilateral in form, having their longest diameter vertical, and separated from each other by the posterior edge of the septum. On looking into them we see the posterior extremities of the turbinated bones and the terminations of the several meatuses. 2. The upper surface of the velum palati (*c a*), forming an inclined plane, which directs the mucous secretions

into the throat. 3. The isthmus of the fauces (2), of a semicircular form, divided into two arches, and exhibiting the pillars, the amygdaloid excavation, and the prominence of the tonsils. 4. The superior opening of the larynx (3), the plane of which is directed obliquely upwards and forwards (see *fig.* 140.); the epiglottis (*i*, *fig.* 140.), which is ordinarily erect, closes this opening by becoming depressed like a valve. 5. The posterior surface of the larynx, with its two lateral and triangular grooves, broad above and narrow below, which have been regarded as specially intended for the swallowing of liquids, which thus pass on each side of the laryngeal opening.

It is extremely curious and highly important to study all the objects displayed in the complicated mechanism of the pharynx: by so doing we learn how the air passes from the nasal fossa and mouth into the pharynx, and thence into the larynx, into which it is drawn by the active expansion of the thorax, without ever entering the œsophagus; how the mucous secretions of the nose, or blood, can pass from the nose down into the mouth and throat; how instruments may be introduced from the nasal fossæ and buccal cavity into the œsophagus and larynx, or drawn from the nose into the mouth; and lastly, how solids and liquids can pass into the œsophagus without entering the air-passages, or why they sometimes take this irregular course.

The *posterior wall of the pharynx* is broader in the buccal region than either above or below: it may be partially seen through the isthmus of the fauces in the living subject. There is no folding of the membrane upon any part of this wall, we only find a few glands forming projections beneath the lining membrane.

On each *lateral wall* is seen the expanded orifice of the corresponding Eustachian tube (4, *fig.* 140.), and a groove leading from it downwards and inwards. This orifice corresponds precisely to the posterior extremity of the lower turbinated bone; an important relation, because it serves as a guide in the now common operation of introducing a catheter into the Eustachian tube.

The roof of the pharynx corresponds to the basilar process: it may be reached by the finger introduced into the mouth, if it be curved directly upwards.

There is no very distinct line of demarcation, either internally or externally, between the pharynx and the œsophagus (*y*, *fig.* 140.). Their limits are established by a sudden narrowing of the tube *, by a change of colour in the lining membrane, and by a change in the direction and colour of the muscular fibres, which are red in the pharynx and much paler in the œsophagus.

Structure of the pharynx. The pharynx is composed of an aponeurotic portion, of muscles, of vessels and nerves, and of a lining mucous membrane.

The *aponeurotic portion*, or framework, of the pharynx is composed of the cephalo-pharyngeal aponeurosis and of the petro-pharyngeal aponeurosis.

The *cephalo-pharyngeal* or posterior aponeurosis of the pharynx arises from the lower surface of the basilar process, from the Eustachian tubes, and from the contiguous parts of the petrous portions of each temporal bone: it is continuous above with the thick periosteum, which covers the basilar process; is prolonged vertically downwards, and, gradually diminishing in thickness, is lost after extending about an inch and a half or two inches. On this membrane the constrictor muscles of the pharynx terminate.

The *petro-pharyngeal* or lateral aponeurosis of the pharynx arises from the petrous portion of the temporal bone internally to the inferior orifice of the carotid canal, by a very thick tendinous bundle, continuous at a right angle with the cephalo-pharyngeal aponeurosis †; it then descends along the sides of the pharynx, and splits into bundles, which are inserted into the pterygoid fossa between the internal pterygoid muscle and the circumflexus palati, separating these muscles from each other. From thence it gives off to the posterior

* [This occurs exactly opposite the cricoid cartilage.]

† The superior cervical ganglion of the sympathetic nerve lies upon the angle formed by these two aponeuroses.

extremity of the inferior alveolar border a fibrous prolongation, to the front of which the buccinator muscle is attached. This aponeurosis covers the tonsil, to which it is closely united. It is prolonged downwards as far as the upper border of the os hyoides, in order to form the framework of the side and lower part of the pharynx.

Muscles of the Pharynx.

The muscles of the pharynx are divided into intrinsic and extrinsic.

The Intrinsic Muscles.

The intrinsic muscles have a membranous form, and are arranged in three successive imbricated layers. Santorini described a great many muscles in the pharynx, on account of their numerous attachments; but Albinus has reduced them to three on each side, named *constrictors*, distinguished into an inferior, a middle, and a superior. Chaussier united all the muscles which enter into the composition of the pharynx, under the collective name of *les stylo-pharyngiens*. The division of Albinus has been generally and justly preferred.

The Inferior Constrictor.

This is a membranous muscle (*w*, *figs.* 141. 147.) of a lozenge or rather a trapezoid shape, the most superficial and the thickest of all the muscles of the pharynx, and is situated at the lower part of that cavity. It is attached, *on the one hand*, to the cricoid and the thyroid cartilages; and, *on the other*, to the fibro-cellular raphé along the posterior median line of the pharynx (crico-pharyngien and thyro-pharyngien, *Valsalva*, *Winslow*, and *Santorini*). It might be called the *crico-thyro-pharyngeus*. It *arises* upon the side of the cricoid cartilage, from a triangular space bounded in front by the crico-thyroideus (*a*, *fig.* 147.), from which it often receives some fibres, and behind by the crico-arytenoideus posticus (*i*, *fig.* 141.).

Fig. 147.

Its *thyroid origins* are much more extensive, and take place from an imaginary oblique line on the outer surface of that cartilage, from the two tubercles at the extremities of that line, and from the entire surface behind it; also from the upper and posterior borders, and from the corresponding inferior cornu of the same cartilage. Having thus arisen by two very distinct digitations, the fleshy fibres pass in different directions: the inferior fibres, short and horizontal, proceed directly inwards; the superior become longer, and are directed more obliquely upwards, in proportion as they approach the upper part of the muscle: they terminate by an expanded border of much greater extent than the outer border, and the upper extremity of which rarely extends above the middle of the pharynx. The transverse direction and the shortness of the inferior fibres have obtained for them the name of the *œsophageal muscle* (*Winslow*, *Santorini*).

Relations. Covered by a dense cellular membrane which surrounds the entire pharynx, and which might be regarded as the proper sheath of its muscles, the inferior constrictor has the same relations posteriorly as the pharynx itself. Externally it is covered by the sterno-thyroid muscle and the thyroid body. It covers the middle constrictor, the stylo-pharyngeus, and palato-pharyngeus, and for a great part of its extent it is in contact with the mucous membrane of the pharynx (see *figs.* 141. 147.). The recurrent laryngeal nerve passes under the *lower margin* of this muscle, near its cricoid attachment, in order to enter the larynx. Its *upper margin* is well defined from the other constrictors by a tolerably distinct ridge, and by the passage of the superior laryngeal nerve beneath it. Winslow states that he has seen some fibres of the muscle arise from the thyroid body; and Morgagni, that he has traced some from the first ring of the trachea.

Action. It is simply a constrictor in its lower portion: its upper fibres act as a constrictor, a depressor, and a tensor of the posterior wall of the pharynx; t can also raise the larynx and carry it backwards.

The Middle Constrictor.

This is a membranous triangular muscle (*v*, *figs.* 141. 147.) situated in the niddle of the pharynx, upon a plane anterior to the preceding.

It *arises* from the os hyoides, and is *inserted* into the posterior median raphé *hyo-pharyngeus*). It arises from the os hyoides in the following manner:—1. from he whole extent of the upper surface of the great cornu below the hyo-glossus *t*), from which it is separated by the lingual artery; a great many fibres arise y a tendinous origin from the apex of this cornu; 2. from the lesser cornu nd the contiguous part of the stylo-hyoid ligament. From these different rigins, which form the external truncated angle of the muscle, the fleshy fibres iverge in various directions; the inferior passing downwards, the middle ansversely, and the superior upwards: the latter are much more oblique and iore numerous than the others, and terminate in a pointed extremity, which ever reaches as high as the basilar process.

Relations. Its *external surface* is in a great measure superficial, and is in lation with the muscles of the præ-vertebral region, through the medium of ie cellular investment of the pharynx. It is covered, in the rest of its extent, y the inferior constrictor and the hyo-glossus. It covers the mucous memrane of the pharynx, the superior constrictor, the stylo-pharyngeus, and the alato-pharyngeus. Its upper margin may be distinguished from the superior onstrictor by its projecting slightly behind that muscle, and by the stylo-haryngeus (*r*), which lifts up this border in penetrating into the pharynx.

Action. It is a constrictor of the pharynx, and can draw the os hyoides pwards and backwards.

The Superior Constrictor.

This is a quadrilateral muscle (*g*, *figs.* 141. 147.) occupying the upper part f the pharynx: it *arises* from the pterygoid process, the mylo-hyoid ridge, nd the base of the tongue; and is *inserted* into the posterior median raphé, *ptérygo-pharyngeus*, *buccinato-pharyngeus*, *mylo-pharyngeus*, and *glosso-pharyngeus*, Santorini).

It arises, 1. by tendinous fibres, from the lower third of the margin of the iternal pterygoid plate and its hamular process; 2. from the contiguous poron of the palate bone, and the reflected tendon of the circumflexus palati; . from the buccinato-pharyngeal aponeurosis, which extends from the pteryoid process to the posterior extremity of the inferior alveolar arch *; 4. from ie posterior extremity of the mylo-hyoid line; 5. the fibres which are said arise from the base of the tongue are nothing more than those fibres of ie genio-hyo-glossus, which Winslow has described as le genio-pharyngien. These are the same fibres, so difficult to demonstrate, which Valsalva and antorini have regarded as forming a particular muscle, denominated by them he glosso-pharyngeus.

From these different origins the fleshy fibres curve backwards, and then ass transversely inwards; the superior form a sort of arch, having its conavity directed upwards (see *figs.* 141. 147.), and are inserted into the cephalo-haryngeal aponeurosis: they form the *cephalo-pharyngeus* muscle of some authors, which is said to be continued from one side to the other without any internediate raphé. This muscle forms a very thin layer, the fibres of which are aler and less distinct than those of the other constrictors.

Relations. Its *external surface* is partly covered by the preceding muscle, nd has behind, and on the sides, the same relations as the pharynx. This

* As this same aponeurosis gives attachment to the buccinator, it may be conceived that the contraction of that muscle cannot be altogether without effect upon the pharynx.

muscle forms the inner side of a triangular space already described (p. 456.) (the *maxillo-pharyngeal*), the outer side of which is formed by the ramus of the lower jaw and the internal pterygoid muscle (*b*, *fig.* 141.), and which is occupied by the internal carotid artery, the internal jugular vein, and the pneumogastric, hypo-glossal and spinal accessory nerves.

Its *internal surface* (*fig.* 141.) is in relation with the pharyngeal mucous membrane, with the levator palati (*c*), which it separates from the circumflexus palati (*d*), and with the palato-pharyngeus (*e*).

Action. It is a constrictor.

Remarks. From the preceding description it follows, 1. That the constrictors of the pharynx form three super-imposed or rather imbricated muscular layers. This imbrication, or overlapping, is so arranged, that the projections (very slight it is true) formed by the upper margins of the constrictors are on the outer not on the inner surface of the pharynx; and this has perhaps some relation to the downward course of the alimentary mass.* 2. That the thickest part of the muscular layer formed by the constrictors is opposite the buccal portion of the pharynx, where the lower and middle constrictors overlap; and that the thinnest part is in the nasal portion, which is formed by the superior constrictor alone. 3. That the pharyngeal insertions of all the constrictors are upon a single line, the median raphé, whilst their points of origin are exceedingly numerous, viz., commencing from below, the cricoid cartilage, the thyroid cartilage, the great and lesser cornua of the os hyoides, the base of the the tongue, the mylo-hyoid line, the buccinato-pharyngeal aponeurosis, and lastly the pterygoid process.

The Extrinsic Muscles.

The extrinsic muscles of the pharynx are generally two in number, the stylo-pharyngeus and the palato-pharyngeus. The latter has been already described among the muscles of the velum palati. It is by no means uncommon to find several supernumerary muscles.

The Stylo-pharyngeus.

This muscle (*r*, *figs.* 143. 147.), which is round above and broad and thin below, *arises* by tendinous and fleshy fibres from the inner side of the base of the styloid process, or rather from the vaginal process surrounding that base. From this point it passes downwards and inwards, becomes wider and flattened as it enters the pharynx between the middle and superior constrictors, to spread out beneath the mucous membrane. Its upper fibres ascend, the middle are transverse, and the lower fibres descend to terminate along the posterior border of the thyroid cartilage † (see *fig.* 143.). These fibres, together with those of the palato-pharyngeus, form the fourth muscular layer of the pharynx.

Relations. Before entering the pharynx, the stylo-pharyngeus is in relation on the outside with the stylo-glossus muscle (*u*), the external carotid artery, and the parotid gland; on the inside with the internal carotid and the internal jugular vein. Its most interesting relation is with the glosso-pharyngeal nerve, which runs along its outer side. Some branches of the nerve often pass through it. *In the pharynx* it is covered by the middle constrictor, and it lies outside the superior constrictor, the palato-pharyngeus, and the mucous membrane.

Action. It raises the larynx and the pharynx.

Supernumerary Muscles of the Pharynx.

Among the supernumerary extrinsic muscles of the pharynx, I shall notice 1. a fasciculus pointed out by Albinus, which I have often met with: it *arises*

* In the construction of pipes or tunnels for the conveyance of water, &c. each piece is received into that below it; an opposite arrangement would facilitate the blocking up of the pipe.

† Some anatomists affirm that they have seen fibres from this muscle reaching the base of the tongue, the epiglottis, and the os hyoides.

from the petrous portion of the temporal bone, and passes into the walls of the pharynx; it is the *petro-pharyngeus* of some authors. 2. A very strong fasciculus, arising from the basilar process in front of the foramen magnum, passing downwards and inwards, and interlacing with its fellow of the opposite side in the median line; it may be called the *occipito-pharyngeus*. 3. A small muscle, which I have seen arising by well-marked tendinous fibres from the summit of the hamular process of the internal pterygoid plate, passing obliquely inwards and downwards, and expanding on the walls of the pharynx; it may be called the *extrinsic pterygo-pharyngeus*. 4. Riolanus has described a *spheno-pharyngeus* arising from the spinous process of the sphenoid, and Santorini and Winslow have noticed a *salpingo-pharyngeus* arising from the cartilaginous portion of the Eustachian tube and the contiguous bone, and blended in the pharynx with the palato-pharyngeus.

Such, then, are the muscles of the pharynx. They are all, as we have seen, constrictors, and at the same time elevators, in consequence of their fibres rising to a greater height internally upon the median line than they do externally; the stylo-pharyngeus alone can be regarded as a dilator. Indeed, dilatation is chiefly effected by the muscles of the os hyoides, by the action of which the larynx is carried upwards and forwards: we may therefore, with Haller, consider them as extrinsic muscles of the pharynx.

Pharyngeal mucous membrane. The muscular semi-canal of the pharynx is lined by a mucous membrane continuous with the buccal and nasal mucous membranes on the one hand, and with those of the larynx and œsophagus on the other. This membrane, which is of a reddish colour, presents some peculiarities at different parts of its extent. Above, near the basilar process, it is thick, and as it were fungous, and closely united to the periosteum, from which indeed it cannot be separated; in this region it is very liable to become the seat of fibrous polypi. Near the posterior orifices of the nasal fossæ and the openings of the Eustachian tubes, it is, in some respects, similar to the pituitary membrane.* It forms a sort of rim around the trumpet-shaped orifice of the Eustachian tube, into which it is prolonged in a remarkable manner, gradually becoming thinner, and at length continuous with the lining membrane of the cavity of the tympanum. This continuity of the mucous membrane of the pharynx and Eustachian tube explains the close sympathy between these parts, and also the deafness which so frequently follows chronic sore-throats and coryzæ, in consequence of the obstruction of these tubes.

In its buccal portion it exactly resembles the mucous membrane, upon the the lower surface of the velum palati: the part covering the posterior surface of the larynx is pale, and forms several folds.

The mucous membrane of the pharynx adheres to the subjacent muscles, only through the medium of very loose cellular tissue, which is never loaded with fat, nor infiltrated with serosity. It is still less intimately adherent to the posterior surface of the larynx.

Its surface is raised by a great number of small glands, chiefly occupying the upper part of the pharynx near the posterior nares: we shall divide them into *agglomerated* and *solitary*. Two agglomerated glands are always situated around the orifices of the Eustachian tube; they open upon the mucous membrane, either separately or together. These glands are sometimes arranged in a line, sometimes in several parallel rows. Haller believes that the salpingo-pharyngeus of Santorini and Winslow is nothing more than a series of these glands united together by fibrous tissue. The solitary glands are scattered over the whole extent of the pharynx. Lastly, the pharyngeal mucous membrane is provided with a thin epithelium †, which can be easily demonstrated by maceration and the action of acids.

* See note, *infrà*.

† [According to Dr. Henlé, the upper part of the mucous membrane of the pharynx is covered with a ciliated columnar epithelium, as far down as a horizontal line extending from the lower border of the atlas to the floor of the nasal fossæ; below that line the epithelium assumes

Vessels and nerves. The pharynx receives a principal *artery* on each side, viz. the inferior pharyngeal, a branch of the internal carotid. The superior pharyngeal branch of the internal maxillary, and some small twigs from the palatine and the superior thyroid, complete its arterial system.

Its *veins* form a very considerable plexus around it (the *pharyngeal venous plexus*), and terminate in the internal jugular and superior thyroid. The *lymphatic vessels* are little known; they pass into the glands lying along the internal jugular vein. Its *nerves* are very numerous, and form a remarkable plexus — the *pharyngeal*, which I regard as one of the largest in the body. They are derived from two sources: — 1. from the cerebro-spinal axis, viz. the *pharyngeal nerve*, a branch of the pneumogastric, which appears to be principally distributed to the muscular layer; the *glosso-pharyngeal*, which appears to be chiefly destined for the mucous membrane; and lastly, some branches of the superior laryngeal and the spinal accessory: 2. from the ganglionic system, several large, grey, and soft branches being distributed to it from the superior cervical ganglion.

This abundance of nerves, and also the sources from which they are derived, will serve to explain, 1. the great sensibility of the pharynx; to which part we refer the feeling of thirst, which some have, therefore, proposed to term the *pharyngeal sense*; 2. the part which it performs in the perception of certain flavours, for example, those of acids; 3. the sympathy between the pharynx, the base of the tongue, and the stomach; 4. the feelings of constriction and strangulation, so common in the pharynx; 5. the spasms with which it is affected in tetanus and hydrophobia; and 6. the nature of the globus hystericus, &c.*

Developement. The developement of the pharynx offers no remarkable phenomena; still it is an exception to the general law of bilateral development, laid down by some anatomists.

Uses of the pharynx. The pharynx is one of the principal organs of deglutition. It serves also for the passage of air in respiration, and as a tube for modulating the voice. The importance of the pharynx in this last point of view and the influence which its different degrees of shortening and constriction exercise upon the compass of the voice, do not appear to me to have sufficiently engaged the attention of physiologists.

The Œsophagus.

The *œsophagus* (οἴσω, I will convey, and φάγω, I eat) is a musculo-membranous canal, an organ of deglutition, intended to convey the food from the pharynx into the stomach. It occupies the lower part of the cervical region and all the thoracic region, and perforates the diaphragm in order to terminate in the stomach.

Directions. It is situated in the median line, resting against the vertebral column: its general direction is straight, for the food does not remain in it; nevertheless, it presents several slight curves: at its commencement it is exactly in the middle line, but inclines somewhat to the left side in the neck; in the upper part of the thorax it deviates slightly to the right side, then again becomes median, and lastly inclines to the left, where it passes through the diaphragm. The general direction of the œsophagus permits the introduction of straight probangs into the stomach. The inflection which it undergoes at its entrance into the thorax, explains the reason why these instruments are sometimes arrested opposite the first rib.

Dimensions. The length of the œsophagus corresponds to the interval

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the squamous form, and is not ciliated. In the Eustachian tube it is also columnar, and provided with cilia, but in the cavity of the tympanum it is squamous, and destitute of those organs.]

* We cannot explain why the syphilitic virus has so serious a predilection for the mucous membrane of the pharynx.

between the pharynx and the stomach, *i. e.* the space between the fifth cervical vertebra, or the cricoid cartilage, and the tenth dorsal vertebra. In regard to its caliber, or *diameter*, the œsophagus is the narrowest part of the alimentary canal. Its diameter is not uniform throughout, the cervical portion* being certainly the narrowest; and therefore foreign bodies, which are too large to pass through the alimentary canal, are generally arrested in the neck. The widest portion of the œsophagus is its lower end.

The œsophagus is capable of a certain degree of dilatation, as is proved by the passage of large foreign bodies for a considerable distance through it (*Mém. d'Hévin, Acad. Roy. de Chirurgie*), sometimes even as far as the stomach. That this dilatability, however, is very limited, may be inferred from the pain caused by swallowing too large a morsel, and also from the stoppage of foreign bodies in the gullet. Nevertheless, in some cases, from external pressure upon, or from stricture of, some part of this canal, it becomes greatly enlarged above the seat of obstruction, and forms a sort of ampulla or dilatation resembling the crop in gallinaceous birds. In one case I found a sort of pouch, or diverticulum, of the mucous membrane, of considerable size, protruding between the separated muscular fibres, and at first sight resembling the crop of gallinaceous birds. An example has been recorded of dangerous suffocation occasioned by the pressure of alimentary matters in a cavity of that kind.

Figure. The œsophagus is cylindrical, and differs from the rest of the alimentary canal in never containing any air, so that (when at rest) its parietes are always in contact. It is somewhat flattened, and as it were compressed, at its upper part; but below it always presents the appearance of a solid cylinder, or a dense firm cord. This appearance exists through its whole extent in some animals, the horse for example.

Like all hollow organs, the œsophagus presents two surfaces, an external and an internal.

The *external surface.* In its long course the œsophagus has many relations, all of which are of great importance, and must be examined in the neck, in the thorax, and in the abdomen.

In its *cervical portion* (*y*, *figs.* 114. 140.) the œsophagus is in relation *in front* with the membranous portion of the trachea (*x*), beyond which it projects a little on the left side. The cellular tissue uniting these two canals is most condensed above. All that portion which projects beyond the trachea comes into relation with the left sterno-thyroid muscle (*n*, *fig.* 114.), the thyroid body (*z*), the left recurrent laryngeal nerve, and the inferior thyroid vessels, which cross it at right angles. The relation of the œsophagus to the trachea explains how foreign bodies arrested in the former passage may compress the trachea, and impede or even prevent respiration. The deviation of the œsophagus to the left is the reason for selecting that side for the performance of œsophagotomy. *Behind*, it corresponds to the longi colli muscles and to the vertebral column, being united to them by loose cellular tissue, so that it is enabled to execute those movements, which are necessary for the performance of its functions. *Laterally*, it corresponds to the thyroid body, the common carotid artery, and the internal jugular vein; but these relations are somewhat modified on each side in consequence of the deviation of the œsophagus. Thus the relations of the œsophagus with the left common carotid are much more immediate than those with the right. The left recurrent nerve lies in front of the œsophagus, the right nerve a little behind it.

Its *thoracic portion* (*o*, *fig.* 161.) is situated in the posterior mediastinum, and is in relation in *front*, commencing from above, with the trachea, then with its bifurcation, and slightly also with the left bronchus, which crosses it obliquely, and which may be compressed by it during the retention of a foreign body, (an example of this accident has been recorded by Habicot); lastly, it is

* [Opposite the cricoid cartilage.]

situated opposite and behind the ascending portion of the arch of the aorta, and the base and posterior surface of the heart, from which parts it is separated by the pericardium. *Behind*, it is in relation with the longus colli and the vertebral column, to which, however, it is not so closely applied as in the neck; nor does it follow the curvature of the spine in the dorsal region, but is separated from it by a space filled with cellular tissue, lymphatic glands, the vena azygos, and the thoracic duct, the latter being placed to its right side at the lower part of the thorax, but passing behind it above, so as to reach the left side. Below, at the point where the œsophagus deviates to the left side in order to gain the opening of the diaphragm, it lies in front of the aorta. On each side it forms a projection along the wall of the mediastinum, which is thus brought into relation with the corresponding lung; it is much more prominent on the right than on the left side. On the *left side* it is also in contact, in its entire extent, with the thoracic aorta (*h*, *fig.* 161.), which is situated a little behind it. Above, it has immediate relations with the arch of the aorta, as that vessel is passing backwards and to the left side of the vertebral column. It is commonly, at this point, that aneurisms of the aorta open into the œsophagus.

In all this region the œsophagus is enveloped by a serous cellular tissue, extremely loose and very abundant; it is surrounded by a great number of lymphatic glands, which have been improperly named œsophageal. These glands when enlarged sometimes compress the gullet so much as completely to arrest deglutition. Lastly, the two pneumogastric nerves run along each side of the œsophagus; inferiorly the left comes in front and the right retires behind the canal: they communicate with each other throughout their course by loops or arches, which perhaps explains the pain caused by swallowing two large a mass of food.

In its *abdominal portion* (if such can be said to exist) the œsophagus is in relation with the œsophageal opening of the diaphragm, below which it is entirely covered by the peritoneum. On the right side and in front it is embraced by the left extremity of the liver; behind, by the lobulus Spigelii. In some subjects the abdominal portion of the œsophagus is an inch in length, but this I think is occasioned by descent of the stomach.

The *internal surface* is remarkable for its pale colour, which contrasts strongly with the rosy hue of the stomach and the upper part of the pharynx, for the wrinkling of its parietes and their contact with each other, and lastly for its longitudinal folds, which seem to have reference to the necessity for its momentary distension during the mere passage of the food through it.

Structure. The œsophagus is essentially composed of two cylindrical membranes, one internal or mucous, the other external or muscular.

The *muscular coat* is remarkable for its thickness, which greatly exceeds that of any other part of the alimentary canal, and is connected with the necessity for the rapid passage of the alimentary mass from the pharynx into the stomach. It is susceptible of hypertrophy, as we find in cases of stricture of the lower part of the gullet. I have seen it five or six lines thick. In all herbivorous animals in which the œsophagus is almost incessantly in action, in those in which the food is carried upwards in opposition to gravity during the act of deglutition, in the horse and in ruminants, the muscular coat is still more developed than in man.

The muscular coat is of a red colour immediately below the pharynx, and rosy through the rest of its extent, but of a darker tint than in the succeeding portion of the alimentary canal. It is of a vivid red in herbivora.*

This coat is composed of two very distinct layers, the external consisting of longitudinal fibres regularly disposed upon all sides of the œsophagus; the internal of circular fibres, in which we shall in vain seek for the spiral arrangement

* [It consists of involuntary muscular fibres (note, p. 426.), intermixed with fibres possessing transverse striæ.]

described by some anatomists as existing in animals and in man.* The longitudinal fibres seem to arise, at least in part, from the posterior surface of the cricoid cartilage, in the median line, between the two posterior crico-arytenoid muscles; they evidently become continuous below with the longitudinal muscular fibres of the stomach. The first muscular ring of the œsophagus appears to arise from the cricoid cartilage; it has been designated the *crico-œsophageus*. There is no sphincter, as some anatomists have affirmed, round the lower extremity of the œsophagus.

The mucous membrane. As Bichat has remarked, the mucous membrane of the œsophagus is perhaps, next to the buccal, the thickest in the alimentary canal. By a remarkable exception (also observed in the rectum) its outer surface is united to the adjacent membrane by a very loose cellular tissue; so that the whole mucous cylinder may be removed entire from the sort of muscular sheath in which it is contained. It has even been said that the muscular coat can force the mucous membrane downwards by its contraction, so as to produce a projecting rim around the cardiac orifice of the stomach, analogous to that which is formed at the anus in prolapsus. The *longitudinal folds* of the mucous membrane are not caused by the contraction and elasticity of the circular fibres of the muscular coat, but depend upon a peculiarity of structure. If the first hypothesis be correct, why should not the mucous membrane also present transverse folds from the action of the longitudinal fibres, for the extremities of the œsophagus are not so fixed, nor is its tension so great that it could not be shortened by the action of these fibres.

Besides the longitudinal folds, there are also in the œsophagus a number of *wrinkles* analogous to those of the skin, and therefore irregular; they appear to me to be caused by the elasticity of the muscular fibres.

The mucous membrane of the œsophagus has a thick *epithelium*, which may be easily shown by maceration and the action of acids, or even without preparation, and which terminates at the cardiac orifice of the stomach by an irregularly fringed or festooned border. †

When examined by the microscope the free surface of the mucous membrane presents a number of small linear ridges, running vertically, and united together by other oblique ridges, so that the whole surface has a reticulated aspect. These ridges are formed by papillæ or villosities, the arteries and veins of which have been accurately figured by Bleuland.

The surface of the mucous membrane is raised in various places by small, oblong, and flat glands found here and there over the entire œsophagus. They were first described by Steno, and should be carefully distinguished from the œsophageal lymphatic glands: the latter are external to the œsophagus, and in certain animals frequently contain small entozoa: they have been supposed to open into the œsophagus, and to deposit within it a fluid containing these animalcules, which some physiologists have regarded as the chief agent in digestion. Any communication, however, between these lymphatic glands and the cavity of the gullet is purely accidental. The true œsophageal glands are very numerous. ‡

In the œsophagus there is only a trace of the *fibrous membrane*, which forms the framework of the alimentary canal; it adheres to the muscular coat, and is, therefore, but loosely attached to the mucous membrane.

There is no external *serous* membrane; it would not have yielded to the instantaneous dilatation required in the œsophagus. The two laminæ of the posterior mediastinum corresponding to its sides, may be regarded as forming the rudiment of a serous coat.

Vessels and nerves. The *œsophageal arteries* are numerous, and arise from several sources. They may be distinguished into the *cervical*, proceeding

* [These fibres are obviously spiral in the ruminant, and many other mammalia.]
† [The epithelium is, in fact, continued on through the rest of the alimentary canal, but becomes thinner, and assumes a different character: in the œsophagus it is squamous.]
‡ [Especially around the lower extremity of the gullet.]

from the inferior thyroid; the *thoracic*, given off either directly from the aorta or from the bronchial and intercostal arteries, and sometimes from the internal mammary; and lastly, the *abdominal*, arising from the coronary artery of the stomach, and the inferior phrenic.

The *veins* terminate in the inferior thyroid, the superior cava, the azygos, the internal mammary, the bronchial, the phrenic, and the coronary of the stomach.

The *lymphatic vessels* enter the numerous glands which surround the œsophagus.

The *nerves* are very numerous, and are derived from the pneumogastrics, which surround the œsophagus with a series of loops; these are joined by some branches from the thoracic ganglia of the sympathetic.

The *developement* of the œsophagus presents nothing worthy of notice.

Functions. The œsophagus is intended to convey the food rapidly from the pharynx to the stomach. This function is performed by its longitudinal fibres shortening the passage, and by its circular fibres contracting it successively from above downwards during deglutition; in vomiting or regurgitation, the contraction proceeds from below upwards.

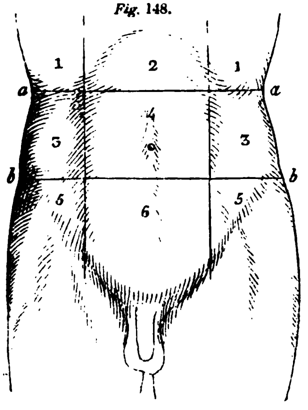
The Stomach.

The *stomach* (γαστὴρ, *ventriculus*), one of the principal organs of digestion, is that wide dilatation (*s*, *fig.* 139.) of the alimentary canal, intervening between the œsophagus (*a*) and the duodenum (*b c*), in which the food is collected and converted into chyme.

Situation. It is situated at the junction of the upper tenth with the lower nine-tenths of the alimentary canal, between the organs of deglutition and those of chylification. It occupies the upper part of the abdominal cavity (*s*, *figs.* 155. 161.), almost entirely fills the left hypochondrium, and advances into the epigastrium, as far as the limits of the right hypochondrium.*

It is maintained in its place by the œsophagus and duodenum, and also by some folds of the peritoneum, which connect it with the diaphragm, the liver, and the spleen. The stomach is, therefore, less subject to displacement than most of the abdominal viscera. It may even be generally stated, that almost all the changes in the relative situation of this organ, are the results of displacements or alterations in the size of those organs which are connected with it. I do not here refer to examples of complete transposition of the viscera, nor to those cases of malformation of the diaphragm, in which the stomach has been found in the thorax.

Fig. 148.



* [In order to facilitate the description of the viscera contained in the abdominal cavity, anatomists have adopted the following artificial division of that cavity into several regions: — The abdomen is first divided into three zones by two horizontal lines, one (*a a*, *fig.* 148.) extending between the most prominent points of the cartilages of the ribs, and the other (*b b*) between the crests of the iliac bones. The superior zone is called the epigastric, the middle the umbilical, and the inferior the hypogastric. These three zones are then subdivided by two vertical parallel lines, drawn from the cartilages of the eighth rib down to the centre of Poupart's ligament. The epigastric zone is thus divided into two hypochondriac (1 1) and a middle epigastric region (2); the umbilical into two lumbar (3 3), and a middle umbilical region (4); and the hypogastric into two iliac (5 5), and a middle hypogastric region (6).]

Direction. The stomach is directed obliquely downwards to the right side, and a little forwards; this direction affords some explanation of the almost constant habit of lying on the right side during sleep, and why the rest is disturbed, and digestion rendered difficult in those who lie upon the left side. Changes in direction of the stomach depend upon the same causes as changes in its situation. Thus, dragging produced by displacement of the small intestine or the omentum, enlargements of the liver or spleen, or the use of too tight stays *, must necessarily affect the direction of this organ. We not unfrequently find stomachs having a vertical direction.

Number. The stomach is single in the human subject as well as in the greater number of animals. The examples of double or triple stomachs in the human subject are merely cases of single stomachs having one or more circular constrictions.† The essential character of a double stomach is not an accidental or even a congenital contraction, but a difference in structure. *Bilocular* stomachs, indeed, are very common; but this form (resembling that of some kinds of calabash-gourds), though sometimes extremely well marked when the stomach is empty, disappears almost entirely when it is much distended by inflation.

Size. In all animals, the stomach is the most capacious part of the alimentary canal; so that in many species, where its limits are not so clearly defined as in man, the existence of a stomach is determined only by the presence of a dilatation. It is of considerable size in herbivora, but comparatively much smaller in carnivora. The human stomach is intermediate between these extremes — a fact which affords evidence of its adaptation to both vegetable and aliment diet. The human stomach, however, presents innumerable varieties in size, from a state of extreme contraction in which it scarcely exceeds the duodenum, to such an enormous degree of dilatation that it occupies a third, a half, or even almost the whole, of the abdominal cavity. These differences depend less upon original variations, than upon its peculiarly dilatable and elastic structure, which enables it to contain a large quantity of food, and to contract more or less completely upon itself when empty. Thus the stomach has a much greater capacity in those who adopt the bad habit of eating only one very full meal in the twenty-four hours, than in those who eat more frequently but less abundantly. In some cases of stricture at the pylorus, it becomes enormously distended. Long continued abstinence occasions such an amount of contraction, that it has even been asserted, that pain resulting from the rubbing of its parietes together gives rise to the feeling of hunger; but this completely mechanical hypothesis should be rejected. In a great number of cholera patients the stomach was found to be exceedingly small. In a female, who died a month after having voluntarily swallowed a small quantity of sulphuric acid, the contracted stomach was not larger than a moderately sized gall-bladder.

Figure. The stomach resembles a flattened cone, curved upon itself backwards and upwards, and having a rounded base; it has been compared to the bladder of a bagpipe. Sections made at right angles to its axis represent circles gradually decreasing in size from the entrance of the œsophagus to the pylorus. We have to examine its external and its internal surface.

The *external surface.* From the peculiar form of the stomach we are enabled to consider an anterior and a posterior surface, a convex border or

* It is impossible to insist too strongly upon the influence of too tight stays on the situation and even the form of the viscera occupying the base of the thorax. Thus changes in the situation and direction of the stomach are much more frequent in females than in males. Sœmmering observed, but without stating the cause, that the stomach is more rounded in the male, and more oblong in the female.

† It may, strictly speaking, be stated that ruminants have only one stomach, the *rennet* or *abomasum*; and that the first three, viz. the *paunch*, the *reticulum*, and the *manyplies* or *omasum*, are nothing more than dilatations of the œsophagus, in which the food undergoes a preparatory elaboration. The same observation applies to birds, in which the crop and the gizzard are not organs of chymification, the first being merely an organ of insalivation, the second one of trituration.

great curvature, and a concave border or lesser curvature, a great cul-de-sac or tuberosity, an œsophageal extremity, and a pyloric extremity.

The *anterior surface* (*upper surface* of some anatomists, *s*, *fig.* 155.), is directed forwards, and a little upwards. When inflated in the dead body with the abdomen open, it is turned directly upwards; but such cannot take place, either in the living or dead subject, when the abdominal parietes are entire; in which case the distended stomach passes in the direction of the least resistance, *i. e.* forwards and downwards, and its anterior surface cannot then be completely turned up.

This surface is in relation with the diaphragm, and is separated by it from the heart; with the liver, which is prolonged upon it to a greater or less extent*; with the last six ribs, being separated from them by the diaphragm; and with the abdominal parietes in the epigastrium — hence the name given to that region. It is not uncommon to find the great omentum turned upwards between the stomach and the liver. When distended, the stomach has much more extensive relations with the epigastrium, or rather with the abdominal parietes, both in a vertical and transverse direction.

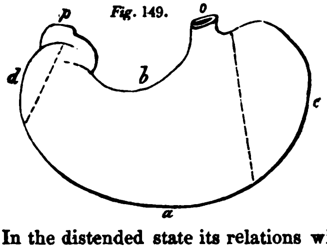
All these relations are of the greatest importance; and with the exception of those which concern the epigastrium, they are constant. In fact it rarely happens that the stomach precisely corresponds to the substernal or xiphoid depression, which has been called the pit of the stomach or the *scrobiculus cordis*, but which belongs neither to the heart nor the stomach. In exploring this depression, it is almost always the liver which is felt; the stomach lies lower down, and is generally below the ensiform appendix.

The *posterior surface* (*inferior surface* of some anatomists, seen turned up at *s*, *fig.* 154.) is directed downwards and backwards, and is seen in the sac of the omentum, of which it forms the anterior wall.

It has relations with the transverse mesocolon, which serves as a floor for it, and separates it from the convolutions of the small intestines; with the third portion of the duodenum (*e'* to *b*), by some of the older anatomists called the pillow of the stomach (*ventriculi pulvinar*); and lastly, with the pancreas (*o*). The duodenum, the pancreas, the aorta (*a*), and the pillars of the diaphragm (*d d*), separate it from the vertebral column, upon which it rests obliquely. These relations are modified by the emptiness or fullness of the stomach.

The *great curvature* (the *inferior* or *anterior border* of some anatomists, *c a d*, *fig.* 149.) is convex, and directed almost vertically downwards in the empty condition of the organ, and almost directly forwards when it is full; it gives attachment to the two anterior layers of the great omentum. It is in relation with the abdominal parietes and the cartilages of the lower ribs, and lies along the transverse arch of the colon (*t*, *fig.* 155.), in front of which it advances when considerably distended; hence it was termed the colic border by Chaussier.

Fig. 149.



In the distended state its relations with the abdominal parietes become much more extensive; but even then I can scarcely believe the assertions of some, that the pulsations of the gastro-epiploic arteries can be felt by the finger in emaciated individuals.

The *lesser curvature* (the *superior* or *posterior border* of some anatomists, *o b p*, *fig.* 149.) is concave, and extends from the œsophageal orifice to the pylorus; it gives attachment to the small or gastro-hepatic omentum; it is directed upwards when the viscus is empty, upwards and backwards when it

* The relations of the anterior surface of the stomach with the liver are very variable in extent; it sometimes reaches even to the gall bladder. I have seen a case in which the gall bladder adhered to the anterior surface of the stomach, and therefore to the left of the pylorus, and communicated with it by an orifice through which bile and biliary calculi were discharged.

is full; and it then embraces the vertebral column in its curvature, being separated from it by the aorta and the pillars of the diaphragm (see *fig.* 154.); it also embraces the small lobe of the liver or the lobulus Spigelii, the cœliac axis (*t*), and the solar plexus of nerves.

The *great extremity* or *great cul-de-sac of the stomach* (the *bottom* or *great tuberosity*, from *c* to the dotted line, *fig.* 149.), comprises all that portion which is to the left of the cardiac or œsophageal opening; it is a sort of semi-spheroid, applied to the base of the cone formed by the rest of the stomach; it is the highest and the largest portion of that organ; it is almost entirely absent in carnivora; it is very large in herbivora, and of a medium size in man. There are also many individual varieties in the size of this portion of the stomach; I have met with some instances in which it was not larger than it is in carnivora.

It is in contact with the spleen (*k*, *fig.* 154.), (hence it is called the *splenic extremity* by Chaussier), with which it is connected by a fold of the peritoneum, called the *gastro-splenic omentum*, and by the vasa brevia. When the stomach is distended it comes into close contact with, and is as it were moulded upon, the spleen (see *fig.* 161.). From this relation a great number of physiological inferences may be deduced.* The great cul-de-sac occupies the left hypochondrium, and corresponds also in the greater part of its extent to the left half of the diaphragm, which is in accurate contact with it, and separates it from the lungs above and from the last six ribs in front. It is more or less elevated, according to the degree of distension of the stomach; and from this we can easily understand that difficult respiration may be caused by too large a meal.

Lastly, it may be stated that the great extremity of the stomach has relations behind with the pancreas, and with the left kidney and suprarenal capsule.

The *œsophageal extremity* (*o*, *fig.* 149.). The œsophagus opens into the stomach at different angles, according to the emptiness or fullness of that organ. The situation of this opening, which is improperly denominated the *cardia* (*cor*, heart), is at the left extremity of the lesser curvature, to the right of the great cul-de-sac, and opposite the œsophageal opening in the diaphragm. It is embraced (*c*, *fig.* 154.) in front by the left extremity of the liver, which sometimes forms a half circle round it, and behind by the lobulus Spigelii. It is surrounded by a circle of vessels and some nerves. Examined externally the lower end of the œsophagus is continuous with the stomach, without any other line of demarcation than that depending upon a difference in size and direction. The peritoneum is directly reflected from the diaphragm upon the œsophagus and the stomach, and forms the gastro-diaphragmatic fold (ligamentum phrenico-gastricum, *Sœmmering*).†

The *pyloric extremity* (*pylorus*, from πύλη, a gate, and οὖρος, a keeper; *p*, *figs.* 149, &c.) is situated at the right extremity of the stomach. It forms the apex of the cone, and presents a circular constriction or strangulation, which exactly defines the limits between the stomach and duodenum. About an inch from this constriction the stomach is much curved, so as to form a decided *bend*, and presents a dilatation, on the side of the great curvature corresponding to an internal excavation, called by Willis the *antrum pylori*, and by others the *small cul-de-sac of the stomach* (from *d* to the dotted line *e*). Not uncommonly we find a second dilatation near the first, and a third, still smaller, on the side of the lesser curvature, resulting from the bend formed by the stomach. The pyloric extremity of the stomach is directed to the right side, backwards and upwards, and sometimes even a little to the left when the stomach is much distended.

* The great end of the stomach is so closely connected with the spleen, that it necessarily follows all displacements of that organ. I have met with a case in which the spleen, three or four times its natural size, was situated in the umbilical region, and had dragged down the great end of the stomach with it. The left extremity of the transverse colon, and the upper part of the descending colon, occupied the place of the great extremity of the stomach. The patient had long suffered from indigestion, which had been attributed to chronic gastritis.

† [Hence this extremity is comparatively fixed.]

The relations of the pyloric extremity with the abdominal parietes are very variable, for the changes in the situation of the stomach chiefly affect this extremity. It corresponds to the limit between the epigastrium and the right hypochondrium; sometimes it is in relation with the gall-bladder, and hence may become stained; in some cases it passes to the right of the gall-bladder, to the extent of an inch or an inch and a half. I have seen it occupying the horizontal fissure of the liver, the edges of which were separated for its reception. Very commonly we find the pylorus in the umbilical region. I have seen it in the hypogastrium in a female who was affected with schirrus of the pylorus, and I have also found it in the right iliac fossa. It is, therefore, extremely difficult to determine the seat of an organic lesion of the pylorus from external examination.

The relations of the pylorus with the abdominal viscera are more constant: above, it corresponds to the liver and the lesser omentum; below, to the great omentum; in front, to the abdominal parietes; and behind, to the pancreas. It is not uncommon to find it adhering to the gall-bladder.

The internal surface. This presents the same regions as the external surface: all its peculiarities may be referred to the mucous membrane, which will be noticed when the structure of the stomach is described. Besides these, however, we observe here the two orifices of the stomach.

The *œsophageal orifice* (cardiac, left, or superior orifice *ostium introitus*; *a*, *fig.* 150.) is remarkable for its radiated folds (ad stellæ similitudinem, *Haller*), which are effaced by distension; for the irregularly fringed border and the change in colour which mark the limits between the mucous membrane of the œsophagus and of the stomach; for its size and its capability of dilatation; and lastly, for the total absence of any valve or sphincter.

Fig. 150.

The *duodenal* or *pyloric orifice* (right or anterior orifice, *janitor*, *sphincter*, *ostium exitus*; *p*) is remarkable for an internal rim or *circular valve*, which in a distended and dried stomach forms a sort of diaphragm (in speciem diaphragmatis, qualia sunt in tubis telescopicis, *Morgagni*); for the narrowness of the passage, which, with difficulty, admits the little finger in most subjects; for its slight dilatability; and lastly, for the existence of a muscular ring, which may be regarded as a true sphincter. It is of importance to remark that this orifice, independently of any disease, presents a great number of varieties in its dimensions, and it is probable that these congenital or acquired variations may have some influence upon its diseases.

The relative position of these two orifices is an important anatomical point. Upon this we should observe, 1. that they are but little apart from each other, considering the size of the stomach, and that the interval between them does not increase in proportion to that size; 2. that the œsophageal orifice is directed upwards, the pyloric opening backwards and a little upwards; 3. that the two openings are not upon the same plane, the œsophageal being higher and more posterior than the pyloric.

The structure of the stomach. In order to study the structure of the stomach, it is necessary in the first place to distend it. Two stomachs are indispensable for this purpose, one to be dissected from without inwards, and the other from within outwards. One of the stomachs should be everted, and then inflated.

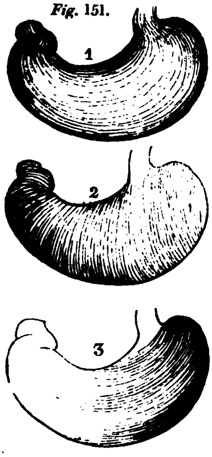
The parietes of the stomach are formed by the super-position of *four membranes* or coats, differing in texture and properties. These, proceeding from without inwards, are the serous, the muscular, the fibrous, and the mucous coats. We must also examine the vessels, nerves, and cellular tissue, which enter into the composition of these parietes.

1. The *serous* or *peritoneal coat.* Like almost all the moveable viscera of the abdomen, the stomach receives a complete covering from the *peritoneum* (*membrana communis* of the ancients; la membrane capsulaire, *Chauss.*). It is formed in the following manner. Two layers of the peritoneum in contact with each other, pass from the transverse fissure of the liver to the lesser curvature of the stomach:—there they separate, so as to leave between them a triangular space, the base of which corresponds to the lesser curvature; the anterior layer then passes over the anterior surface of the stomach, and the posterior covers it behind; they again approach each other at the great curvature, along which they form another triangular space, exactly resembling that which we have already described as existing at the lesser curvature, and then unite so as to form the two anterior layers of the great omentum (see description of *Peritoneum*). The same arrangement takes place at the great extremity of the stomach. Bloodvessels pass round the stomach, along the line where the two layers of the peritoneum are applied to each other at its two curvatures.

The peritoneum, therefore, forms a complete covering for the stomach, excepting at the curvatures, where we find triangular spaces, into which the stomach is forced during its distension. I doubt whether these triangular spaces can afford sufficient space for the stomach when greatly distended, and I believe that, in such cases, the two anterior layers of the great omentum separate, and are applied upon that organ. It is evident, besides, that distension of the stomach chiefly affects its great curvature.

The peritoneal coat does not adhere firmly to the subjacent tissues of the stomach, in the neighbourhood of either curvature; but it is closely united to them at the middle points of both surfaces. The imperfect extensibility of the peritoneal coat requires such an arrangement as exists along the curvatures. I have observed some small fibrous bands in the sub-serous cellular tissue along the lesser curvature, which must be intended to maintain the shape of that part. The uses of the peritoneal coat, in reference to the stomach itself, are merely mechanical; it strengthens, preserves the shape, and facilitates the movements of this organ.

Fig. 151.



The muscular coat. This coat has engaged much of the attention of anatomists, since the time of Fallopius, who was the first to give a correct description of it; and to whom Morgagni (*Advers. Anat.* iii. p. 6.) has attributed the honour of discovering it, in opposition to the claims of Willis. Helvetius made it the subject of a special work. (*Hist. Acad. Roy. des Sciences*, 1719.)

We shall describe, in accordance with Haller (*Elem. Phys.* tom. vi. lib. xix. sect. i. p. 126.), and the majority of anatomists, three layers of muscular fibres.

The *superficial* or *longitudinal layer* (1, *fig.* 151.) is formed by a continuation of the longitudinal fibres of the œsophagus, which spread out in a radiated manner from the cardiac orifice of the stomach. They are scattered thinly over its surfaces, the great curvature, and the great extremity, but are collected into a band along the lesser curvature, the shape of which they assist in preserving. On account of this arrangement they have received the name of *cravate de Suisse.*

These fibres form a continuous plane of considerable thickness over the contracted portion of the stomach near the pylorus. In this situation they are stronger, and fasciculated, and appear partly to terminate in the pyloric constriction, and partly to be continued upon the duodenum.

The *second* or *circular layer* (2, *fig.* 151.) is composed of fibres which cross the axis of the stomach at right angles, so as to form a succession of rings from the œsophagus to the pylorus. They are few in number at the great extremity of the stomach, but become much more numerous towards the pylorus, throughout all the contracted portion of the stomach. At the pylorus itself they form a thick ring, which forms a sort of rim, projecting in the interior. I have always found this more developed in old age than at any other period of life. It is a true sphincter, which by its contraction effectually opposes the passage of food and gas from the stomach into the duodenum. It is not uncommon to find the whole of this ring, or a half, or two thirds of it, increased to the thickness of three or four lines, independently of any organic lesion.

The older anatomists admitted also an œsophageal ring (or *œsophageal sphincter*), similar to that at the pylorus, and having the power of closing the œsophageal orifice. This, however, does not exist; the last circular fibres of the œsophagus do not form a thicker layer than the others.

Lastly, the different rings formed by the circular fibres of the stomach intersect each other obliquely at very acute angles. The spiral arrangement admitted by Santorini cannot be demonstrated.

The *third muscular layer* (3, *fig.* 151.), which I have only been able to see distinctly upon hypertrophied stomachs, is composed of *looped* or *parabolic fibres*, the middle portions of which embrace the great end of the stomach, extending from the left side of the cardiac orifice obliquely downwards towards the great curvature, while their anterior and posterior extremities are situated upon the corresponding surfaces of this viscus. The superior loops reach the lesser curvature, the inferior the great curvature, and the intermediate loops seem to be lost upon either surface, or rather to become blended with the circular fibres. This layer of fibres appears intended to compress the great extremity of the stomach, and to push the food into the body of the organ, towards the pylorus.

From what has been stated it follows, that, excepting in the vicinity of the pylorus, the muscular layers of the stomach do not form a continuous plane, but have an areolar disposition: the areolæ or spaces between the different fibres are of considerable size; hence the necessity for a strong membrane, like the fibrous coat, which, as we shall find, constitutes the framework of the stomach.

The muscular fibres of the several layers are much paler than those of the œsophagus.* They have a pearly appearance when seen through the peritoneal coat, which has led to the supposition that they are tendinous. Hence the error of Helvetius, Winslow, and others, who regarded the two white lines running along the two surfaces of the stomach, between the curvatures, as *ligaments of the pylorus*; they are nothing more than longitudinal muscular fibres. Other authors have merely admitted some tendinous intersections of these fibres.

The muscular coat is not uniformly thick at all points. It is very thin at the great cul-de-sac, and becomes much thicker towards the pylorus. It also presents many varieties in different subjects; it is but slightly developed in large stomachs, and much more so when this organ is contracted. There is a physiological as well as a pathological hypertrophy of the muscular coat. In the latter it has been found seven or eight lines thick.

The fibrous coat. This coat, the existence of which has been alternately admitted and denied, is situated between the muscular and the mucous coats, and is quite distinct from both. It was known by the ancients as the *membrana nervosa* †; it constitutes, properly speaking, the framework of the organ. In order to demonstrate this coat it is sufficient to remove the peritoneal and mus-

* [They are principally of the involuntary class, but have a few striated fibres among them (see note, p. 426.)].

† [So called from its *white* appearance.]

cular tunics, and then to evert the stomach and remove the mucous membrane. This experiment will also very clearly show the great strength of the fibrous coat, which, even thus unsupported, can bear considerable distension; while, on the other hand, when this coat has been divided, the remaining membrane or membranes burst through the opening thus made.

This coat should not be confounded with the dermis of the mucous membrane, for it adheres much more strongly to the muscular coat, into which it sends numerous prolongations, than to the mucous membrane, with which it is connected only by loose cellular tissue.

The fibres of this coat have not a parallel arrangement like those of aponeuroses and fibrous sheaths, but they form a very dense network, the filaments or lamellæ of which can be separated by inflation or infiltration. It is concerned in a very important manner in chronic diseases of the stomach: it is very liable to hypertrophy; and, in certain cases, acquires a thickness of several lines.

The mucous membrane. The history of this membrane is curious. It was for a long time confounded with the mucus, by which it is covered, being regarded as merely a dried layer of that secretion.* It was pointed out by Fallopius, who applied to it the very appropriate appellation of the *velvet-like tunic*; but it was first described as a separate membrane by Willis, under the title of the *glandular tunic*. The discovery was confirmed by the beautiful injections of Ruysch, who gave it the name of *epithelium*; to which term, however, he did not attach the same meaning as modern authors. It was afterwards regarded as an epidermic membrane, analogous to the epidermis of the skin †, and capable of being thrown off and renewed. In recent times it has been supposed to be concerned *tanquam omnium lerna malorum*; and has become in the present day the object of a great number of most interesting researches.

The mucous membrane of the stomach presents an adherent and a free surface. The *adherent surface* is united to the fibrous coat by cellular tissue, so loose as to permit very free motions. The *free surface* has the following characters. When the stomach is strongly contracted, it forms a number of folds (see *fig.* 150.), the principal of which are longitudinal; these folds disappear when the organ is distended, as may be shown in an everted stomach. Their only use is to allow of the rapid distension of this organ, a condition that could not have been attained in any other mode, in consequence of the slight elasticity of the mucous coat.

These longitudinal and temporary folds, which are perfectly distinct from the permanent folds observed in other parts of the alimentary canal, are most strongly marked near the pylorus; they are extremely regular, sometimes straight and sometimes flexuous; and they proceed parallel to each other from the cardiac towards the pyloric orifice. They are intersected more or less obliquely by other winding folds of different degrees, which often give an areolar appearance to the internal surface of the stomach.

From this arrangement it follows that dilatation of the stomach occurs principally in a direction across its long axis; the resources for dilatation in the direction of its axis are much less numerous. Of all the folds of the mucous membrane, the most important is undoubtedly that called the *pyloric valve*, which is often nothing more than a mere elevation of the membrane by the sphincter muscle. ‡ This circular fold is equally opposed to the regurgitation of food from the duodenum into the stomach, and to its passage from the stomach into the duodenum; it is completely effaced by distension, and it belongs as much to the duodenum as to the stomach. Its upper half has the characters of the gastric; the lower half offers those of the duodenal mucous

* Riolanus states positively (*Anthropol*, l. ii. c. xii. p. 171.) that the stomach, like the intestines, is composed of three coats, viz. a common external membrane, a nervous, and a muscular coat; and that a closely adherent mucus, consisting of the thickest part of the chyle, lines it on the inside.

† Such was the opinion of Haller, lib. xix. p. 132.

‡ [It usually consists of the mucous membrane, the cellular coat, and the *circular* muscular fibres.]

membrane. Diseases are sometimes observed to stop at the line of separation. We may add, that the folds upon the internal surface of the stomach are formed by the mucous membrane alone, the fibrous coat does not enter into them.

Besides these folds, the mucous membrane presents numerous slight and tortuous *furrows*, dividing it into small spaces or compartments, which are either lozenge shaped, hexagonal, polygonal, circular, oblong, or irregular.

Examined by the naked eye, the mucous membrane has a soft, spongy, tomentose, or velvety appearance; hence the name of *villous* or *velvet-like membrane*, by which it is still generally known. It is covered by a layer of mucus of variable thickness, which may be detached by friction with a coarse cloth. In order to avoid the inconveniences arising from this method, which is more or less injurious to the texture of the membrane, I have been accustomed to use a gentle stream of water, which at the same time that it completely washes away the mucus, clearly displays the papillary structure of the surface of the membrane.

There are some stomachs which might be called *granular* or *glandular*, because the mucous membrane has a granular appearance, so that at first sight it might be imagined that some small glandular bodies (like the salivary glands) were scattered over the internal surface of the stomach; but this glandular aspect is merely apparent, depending upon the circular or semicircular direction of the furrows in the mucous membrane, which give a spheroidal character to the kind of islets that are intercepted between them. This granular appearance is seldom observed over the entire stomach; it rarely exists at the great extremity. I have found it limited to the great curvature; most frequently it occurs in the vicinity of the pylorus; sometimes it is observed over all that part of the stomach which is to the right of the œsophagus. These granulations are particularly developed in the stomach of the pig.

There is one remark upon which too much importance cannot be placed; and that is, the difference in the appearance of the mucous membrane of the great extremity of the stomach, and of the part situated to the right of the œsophagus. Sometimes the line of separation forms a perfect circle; and this is a very remarkable fact, because in man, who has a single stomach, it may be considered as a rudiment of the division into the compound stomachs found in the lower animals; for a multiple stomach results rather from some difference in the structure of the mucous membrane, than from the existence of different compartments or distinct cavities. It will not be uninteresting to connect this remark, with what has been already stated regarding bilocular stomachs.

We shall now examine the characters of the mucous membrane in the *œsophageal* and in the *pyloric* portion of the stomach.

In the œsophageal portion it is thinner, softer, and more vascular, and can only be separated in flakes from the subjacent parts. When the stomach contains any liquid after death, this part is converted into a sort of pulp, which becomes of a blackish colour from the action of the acids in the gastric fluid upon the blood contained in the vessels of the stomach. This is the *pultaceous softening*, which I regard as a post mortem change, but which has been erroneously confounded with the *gelatiniform softening*. The second portion of the mucous membrane, *i.e.* the part situated to the right of the œsophagus, is thicker, stronger, and whiter, and may be separated entire from the other coats. Diseases often observe the line of separation between the right and the left portions of the stomach.

Modern pathologists having attached great importance to the condition of the gastric mucous membrane, it has become highly interesting to determine its characters in the healthy state; these characters relate to its colour, its consistence, and its thickness.

Colour. It is extremely difficult to determine what *is the natural colour of this mucous membrane.* The opinion generally maintained by the best author-

ities, that it is either primarily or secondarily affected in the majority of diseases, compels us to reject all observations made upon persons who have died from acute or chronic diseases, or even from wounds or injuries of long standing. We are therefore obliged to have recourse to cases of accidental death in persons previously in health. In such cases, for example, in criminals who are executed whilst the stomach is empty, the mucous membrane is found of a greyish white colour, with a slight tint of yellow and pink.* When death has occurred during digestion, the mucous membrane is found to vary from a delicate pink to the most vivid red. After putrefaction has made some little progress, we find a red or port wine colour, or a brownish black tint prevailing over the great extremity of the stomach, and at the free edges of the folds or wrinkles to which the vessels correspond; again, it is often found marked with blackish patches, or marbled; but these discolourations are the result of post mortem transudation.

In the pultaceous and blackish softening of the mucous membrane, the colour is owing to the action of the acids in the gastric juice. When the stomach contains bile, the mucous membrane is tinged with yellow or green, and the stain sometimes remains after the longest maceration.

If the mucous membrane be rubbed with a rough cloth, so long as the vessels contain blood, we may produce a red punctuated appearance, which has been often mistaken for a sign of inflammation. Lastly, in the aged we not unfrequently observe a slate grey colour, either in points or in patches, or diffused over the surface. This colour occupies the papillæ, and may afford proof of some former irritation, but is certainly not due to any diseased action during the later periods of life. These different discolourations of the stomach must not be confounded with the alterations in its colour resulting from disease.

Thickness. It is difficult to estimate the exact thickness of the gastric mucous membrane. Like the muscular coat it varies in different individuals; in chronic inflammation it is twice or three times its natural thickness. In determining the thickness of this membrane, it is important to bear in mind the difference in this particular, between the œsophageal and pyloric portions; the former being extremely thin, and the latter twice or three times as thick as that.

Consistence. The same remarks apply to its consistence, for there are many individual varieties in this respect. The œsophageal portion may be torn with great ease; but the pyloric portion is so dense that the back, and even the edge of a scalpel may be drawn over it with considerable force without wounding it. If there has been any liquid, or even food in the stomach, in however small quantity, the mucous membrane of the œsophageal portion, when macerated, is converted into a pulp; moderate distension will then rupture the walls of the stomach, which may be broken through by the point of the finger.

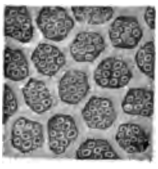
From want of sufficient reflection upon this subject, men of great merit have committed serious errors in the appreciation of morbid lesions. In the gelatiniform softening the gastric mucous membrane, as well as the other coats of the stomach, become dissolved and resemble a solution of gelatine. In many old people, and in some adults, I have found the mucous membrane so thick and so strong, that it could be dissected off entire, and removed in one piece. This condition co-existed with the slate colour, either accompanied or not with chronic inflammation.

The papillæ. If we examine the mucous membrane of the stomach, placed under water, and exposed to the direct rays of the sun by the aid of a powerful lens, we shall find that its surface is very irregular, mamillated, and furrowed, so as to present an appearance very like the convolutions of the small

* In a great number of individuals who have died from acute or chronic diseases, the gastric mucous membrane is found in the same state as in those who have died accidentally; it is, therefore, not always affected, either primarily or secondarily, in disease.

intestine. The eminences, which are much more distinct towards the pylorus than near the œsophagus, are studded with holes, or rather with small pits resembling the cells of a honey-comb (*figs.* 152, 153.). These alveolar depressions are well described by Home, who states that they exist only in the great cul-de-sac, while the villi occupy the rest of the stomach. The truth is, that a precisely similar structure is observed over the whole stomach. The alveoli, or pits, are separated from each other by small projections or *papillæ* (*fig.* 153.), of which the papillæ of the tongue convey an excellent idea.*

Fig. 152.



Magnified 32 diameters.

Fig. 153.

Magnified 32 diameters.

Should these papillæ be distinguished from other projections that have been termed *villi*, by Ruysch, for example, who called the entire membrane *villoso-papillaris*? After the most minute examination, I have only detected one order of eminences †, viz. the *papillæ*, the existence of which I regard as the essential character of all tegumentary membranes, whether mucous or cutaneous, which might all, therefore, be designated *papillary membranes*. We shall return again to the structure of the papillæ.

If we examine with a lens or simple microscope, a perpendicular or oblique section of the mucous membrane of the stomach, we shall perceive that it consists essentially of a strong membrane, the mucous dermis, from which arise an immense number of small eminences closely pressed together, and of unequal lengths, like the pile of velvet. These eminences are the papillæ; they are liable to great enlargement in cases of hypertrophy, and then the structure just described becomes very apparent.

The follicles. The follicles of the stomach can be very easily demonstrated in the pig ‡, and in the horse. In the last-mentioned animal, entozoa are frequently found in the centre of these follicles, which then become developed into hard, and sometimes very large, tumours. It is so difficult to demonstrate them in the human subject, that, with most anatomists, I for a long time doubted their existence. Haller only saw them once or twice §; but in some individuals they are very distinct. I found them well marked in a great number of cholera patients.‖ They are not situated in the submucous cellular tissue, as is generally stated, but in the substance of the membrane itself, so as to form a projection on the inside of the stomach, but not on the outer surface. They are rounded, flattened, and perforated by a central foramen, which is usually visible to the naked eye. I have observed them upon all points of the mucous membrane, but they appear to be most numerous near the œsophageal orifice, and along the lesser curvature.¶

* [The alveoli are from $\frac{1}{350}$th to $\frac{1}{200}$th of an inch, and, near the pylorus, $\frac{1}{100}$th of an inch in diameter. At the bottom of each alveolus is seen a group of minute apertures (*fig.* 152.), which are the open mouths of small tubes placed perpendicularly to the surface of the membrane, and closed at the other end. In a vertical section of the membrane these tubes, which average about $\frac{1}{500}$th of an inch in diameter, are seen to rest upon the submucous tissue by their closed extremities. In the cardiac portion of the stomach they are short and straight; near the pyloric end they are longer, and convoluted, or irregularly dilated, and are sometimes bifurcated. Bloodvessels pass up between these tubes, and form a capillary network round the borders of the alveoli. The membranous projections, sometimes found between the alveoli (*fig.* 153.), form irregular fringes, broader than the lingual papillæ, and seem rather to be imperfectly developed villi (see note, p. 477.), and are usually so called. The epithelium covering the entire mucous membrane of the stomach, consists of a single layer of minute columnar cells; it is very delicate, and invisible except by a high magnifying power; hence its existence was formerly denied.]

† Upon this subject see the Memoir of Helvetius. (*Hist. Acad. Roy. des Sciences*, 1720.)

‡ [In the pig these follicles appear to be nothing more than prolongations of the mucous membrane, or small diverticula; so that, after having detached the mucous membrane, they may, by slight pressure, be turned inside out.]

§ "Neque rejici debent, etsi non semper possint ostendi." (*Haller*, l. vi. lib. xix. p. 140.)

‖ Vide Anat. Path. avec planches, liv. xiv. pl. 1.

¶ [In the neighbourhood of the œsophageal orifice there are also several small compound glands, analogous to Brunner's glands in the duodenum. (W. S.)]

The vessels and nerves of the stomach. The *arteries* are very large and numerous in proportion to the size of the stomach; they must therefore assist in the performance of some function, besides the mere nutrition of the organ; this function is the secretion of the gastric juice. They all arise from the cœliac axis, and are the coronary, the superior pyloric and right gastro-epiploic branches of the hepatic, and the left gastro-epiploic and vasa brevia, which are branches of the splenic artery. These arteries anastomose, so as to form around the stomach a vascular zone, which is in close contact with that organ during distension, but at some distance from it when empty. From this arterial circle branches are given off, which at first lie between the peritoneal and the muscular coats; but after a certain number of divisions and anastomoses, perforate the muscular and fibrous coats, and again subdivide and anastomose a great number of times in the loose submucous cellular tissue, until having become capillary, they penetrate the mucous membrane.

The *veins* bear the same name, and follow the same direction as the arteries; they contribute to form the vena portæ. Schmiedel (*Variet. Vasorum*, No. xix. p. 26.) has seen the coronary vein of the stomach anastomose with the renal vein; the pyloric with the vena azygos, and one of the venæ breves with the phrenic vein.

The *lymphatic vessels* are very numerous, and terminate in the lymphatic glands, situated along the two curvatures of the stomach. The peculiar ducts, said to proceed from the spleen to the stomach, and supposed by the ancients to be passages for the *atra bilis*, are purely imaginary.

The *nerves* are of two kinds, some being derived from the eighth pair, and others from the solar plexus.

The nerves of the eighth pair form a plexus round the cardiac orifice; the left nerve being distributed upon the anterior, and the right upon the posterior surface of the stomach. They may be followed as far as the muscular coat, where they seem to be lost; division of them paralyses this coat. By means of the nerves of the eighth pair, the stomach is connected with the œsophagus, the lungs, the pharynx, the larynx, and the heart. Through the nerves derived from the central epigastric plexus, and named after the arteries that support them, the stomach is connected with the ganglionic system, and is brought into relation with the numerous viscera of the abdomen.

Lastly, a very delicate *serous cellular tissue* unites the different coats of the stomach. There are three layers of this tissue, viz. one between the peritoneal and the muscular coats, another between the muscular and the fibrous, and a third between the fibrous and the mucous coats. The last of these is the most distinct; it is liable to both serous and sanguineous effusions, and may become the seat of diffuse inflammation. I have lately seen it infiltrated with pus to a considerable extent, the mucous and the fibrous coats being both perfectly healthy.

Developement of the stomach. The stomach of the fœtus is remarkable on account of its vertical position, which is due to the great developement of the liver, especially of its left lobe. An unnatural developement of that lobe will also occasion a similar position of the stomach in the adult. The relative smallness of the stomach, and the slight developement of its tuberosity, are also characteristic of its fœtal condition.* Nevertheless, from the first moment of its appearance, it is distinguished from the rest of the alimentary canal by its greater size. The changes which the adult stomach undergoes, and the variations in size which it presents, are perhaps less dependent upon congenital differences than upon particular habits. The differences in the two sexes are manifestly due to the pressure, to which the stomach of the female is subject, either from the use of stays, or from the gravid uterus. I may here advert

* [At early periods of fœtal life, villi are found on the mucous membrane of the stomach generally, afterwards on the pyloric portion only; and, subsequently to birth, the only traces of these are the irregular fringes observed here and there between the alveoli.]

to the developement of the muscular ring of the pylorus, and of the neighbouring part of the stomach in aged persons.

Function. The stomach is the organ of chymification, or of that process by which the food is converted into a homogeneous grey pulp, called *chyme.* For that purpose it is evidently necessary that the food should remain for some time in this organ, and the elasticity of the muscular coat of the œsophagus and of the ring at the pylorus, are sufficient to prevent its regurgitation into the gullet, or its passage into the duodenum. When the process is completed, however, the peristaltic contraction of the muscular fibres of the stomach overcomes the resistance of the pylorus; in eructation, regurgitation, and vomiting, the same peristaltic movements are assisted by the contraction of the diaphragm and the abdominal muscles.

Chymification is a chemical, or at least a molecular, action, and is effected by means of the gastric juice, mixed with the salivary and œsophageal secretions. These fluids are acid.*

The influence of the nerves upon digestion has been ascertained by ingenious experiments, the results of which however have been interpreted in various ways.

The Intestines in general.

The term *intestine*, in its widest signification, is applied to the whole alimentary canal; but, in a more limited sense, it means that long and frequently convoluted tube, extending from the pylorus to the anus, and occupying almost the whole of the abdominal cavity. The intestines have been divided according to their caliber into the *small* (*b* to *d*, *fig.* 139.) and the *large* (*e* to *i*); this distinction, which is applicable to most animals, is anatomically established in man, by a difference in size, by the sacculated character of the large intestine, by a difference in direction, by the presence of a valve, by the existence of a cæcum and of a vermiform appendix, and, lastly, by a difference in structure, especially in the muscular and mucous coats. The same distinction is recognised in physiology, and upon equally good grounds, for the small intestine is essentially concerned in the formation and absorption of the chyle, while the large intestine is the organ of defæcation.† These differences will be rendered more apparent from the description of these two important parts of the alimentary canal.

The Small Intestine.

The *small intestine* includes all that part which is situated between the stomach and the large intestine (*b* to *d*, *fig.* 139.). According to Haller, Bichat, and their followers, the upper portion, called the *duodenum* (*b* to *c*), should be abstracted from the small intestine, which, according to them, would commence at the termination of the duodenum. It appears to me that the former definition should be adhered to, on account both of the absence of any real line of separation between the duodenum and the rest of the small intestine, and of their similarity in structure and function.

The small intestine is divided into three parts, the *duodenum*, the *jejunum*, and the *ileum.* The division between the duodenum and the rest of the small intestine is definite, but that between the jejunum and the ileum is altogether arbitrary; so that we shall follow the example of Haller, Sœmmering, and others, in describing the jejunum and ileum together (*c* to *d*), under the name of the small intestine, properly so called.

* [The saliva, though sometimes acid, is usually alkaline.]

† The division into a small and large intestine exists among all vertebrated animals; but no animals, excepting the ourangs and the wombat, have both a cæcum and an appendix vermiformis. In some we find one cæcum, or several cæca; in others one or more vermiform appendices; others have neither cæcum nor appendix, but a valvular fold and a well-marked change in diameter indicate the limit between the small and large intestines. In some, again, the only difference consists in a change of diameter.

The Duodenum.

Dissection. When the abdomen is opened, the first portion only of this intestine is visible; the second is hid by the ascending colon; the third is seen in the cavity of the omentum. The second is brought into view by turning aside the colon. The third portion, which is the most difficult to demonstrate, may be exposed in two ways, either by cutting through the inferior layer of the transverse mesocolon, or by turning the stomach upwards, after having divided the layers of the great omentum, which are attached along its greater curvature.

The *duodenum* (δώδεκα δάκτυλον, *p b, fig.* 154.), so called by Herophilus (Galen, *Administr. Anat.* lib. vi. c. 9.), on account of its being about equal in


Fig. 154.

length to the breadth of twelve fingers, commences at the pylorus and terminates without any precise line of demarcation, to the left of the second lumbar vertebra, at the point where the small intestine enters into the mesentery, or rather opposite the superior mesenteric artery (*m*) and vein which pass in front of it. Its fixed position, its structure, and its curvatures, have led to its being described separately.*

It is difficult to determine its precise situation with regard to the abdominal parietes. It is not exclusively confined to any one region, but occupies in succession the adjacent borders of the right hypochondrium and the epigastrium, of the right lumbar and the umbilical regions, and of the epigastric and umbilical regions.

The duodenum is found more deeply situated in proportion as we recede from the pylorus, and hence the difficulty of exploring it through the parietes of the abdomen. It is fixed firmly in its place by the peritoneum, by the mesenteric vessels and nerves, which bind it down, and by the pancreas. This fixedness is one of its principal peculiarities, and is indispensable in consequence of its relations with the ductus communis choledochus; for had it been moveable like the rest of the small intestine, incessant obstructions to the flow of the bile would have occurred. It follows also that the duodenum can never form part of a hernia; its first portion may, indeed, be displaced, for it is less firmly fixed than the remainder, and is sometimes dragged out of its proper situation by the pyloric extremity of the stomach.

* Glisson considered the insertion of the ductus communis choledochus, as the lower limit of the duodenum.

Dimensions. It is eight or nine inches in length; its caliber is somewhat greater than that of the rest of the small intestine, but the difference is not so decided as to warrant the names of *second stomach*, or *ventriculus succenturiatus*, which have been given to it. I have even met with subjects in whom the duodenum, when moderately distended, was five inches, while the succeeding portion of small intestine was six inches in circumference. It has been supposed that this part is more dilatable than the rest of the small intestine; this has been attributed to the absence of the peritoneum. The fact and the explanation are equally without foundation. It is the fibrous membrane, and not the peritoneal coat, which is opposed to dilatation of the intestines.

Direction. This is very remarkable. Commencing at the pylorus, the duodenum passes upwards to the right side and backwards; having reached the neck of the gall bladder, it suddenly changes its direction, and becomes vertical, forming an acute angle with the former portion; this is its *first curvature* (*e*): then, after proceeding vertically through a variable space, it passes transversely from the right to the left side, and becomes continuous with the rest of the small intestine. This change in its direction takes place at a right angle, and is, therefore, less abrupt than the former; the point at which it occurs is called the *second curvature* (*e′*).

It follows then that the duodenum describes a double curve, or rather one single curve, of which the concavity is directed towards the left, and the convexity to the right side. Haller has ingeniously compared the course of the duodenum to two parallel lines, intersected by a perpendicular. This double change in the direction of the duodenum, which is probably intended to retard the passage of the food, enables us to consider it as composed of *three portions*, distinguished as the *first* (*p e*), *second* (*e e′*), and *third* (*e′ d*).

Relations. These should be studied in each of the three portions.

Relations of the first portion. Above, with the liver (*l′*, *fig.* 154.*) and the gall-bladder (*g*), to the neck of which it is united by a fold of the peritoneum. It is not uncommon to see the gall-bladder and the duodenum closely adherent to each other, and to find an opening through which biliary calculi have passed into the gut. *In front*, with the gastro-colic omentum and the abdominal parietes. *Behind*, with the hepatic vessels, and the gastro-hepatic omentum. This portion of the duodenum, which may be denominated the hepatic, is about two inches in length.

Relations of the second portion. In front, with the right extremity of the arch of the colon (*t*, *fig.* 161., *e* being the duodenum), which crosses it at a right angle. *Behind*, with the concave border of the right kidney, along which it descends to a greater or less distance, together with the vena cava inferior and the ductus communis choledochus. Sometimes this portion is not in relation with the kidney, but rather with the vertebral column. The ductus communis choledochus (*c*, *fig.* 169.) and the pancreatic duct (*u*) enter the intestine at the posterior and inner surface, and below the middle of this portion of the duodenum. The relations of the duodenum behind are direct, *i. e.* without the intervention of the peritoneum. *On the right*, this portion of the duodenum is in relation with the ascending colon (*a*, *fig.* 161.). *On the left*, with the pancreas (*o*, *fig.* 154.), which is closely united to it, and embraces it in a sort of half groove. This second portion is two or three inches in length; it may be called the renal portion.

Relations of the third portion. The third portion is situated in the substance of the adherent border of the transverse mesocolon. *Below*, it rests upon the lower border of that fold. *Above*, it is bounded by the pancreas, which adheres closely to it. In *front*, it corresponds to the stomach, from which it is separated by the layer of peritoneum which lines the sac of the great omentum. *Behind*, it corresponds to the vertebral column, from which it is separated by the aorta (*a*), the vena cava, and the pillars of the diaphragm (*d d*). †

* In which figure the liver and stomach are turned upwards.

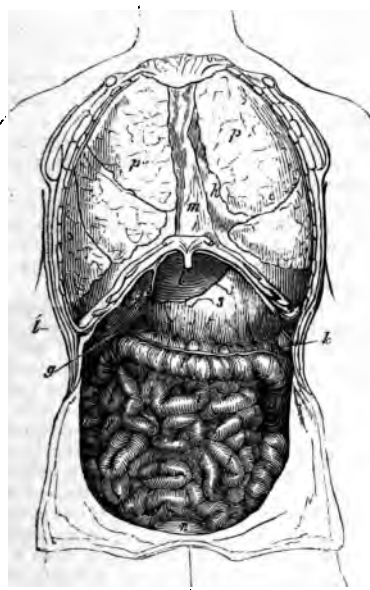
† In one subject I found a fourth portion which passed upwards, and was about one inch in length, so that the duodenum described a third curve with its concavity directed to the right.

As the internal surface and the structure of the duodenum are very analogous to those of the jejunum and ileum, I shall postpone their description until I have noticed the external conformation of the rest of the small intestine.

The Small Intestine, or the Jejunum and Ileum.

The *small intestine*, properly so called (*c d*, *fig.* 139.; *i i i*, *fig.* 155.), or the *jejunum and ileum*, consists of that portion of the alimentary canal which fills almost the whole of the abdomen, occupies the umbilical, hypogastric, iliac, and lumbar regions, and is surrounded, as it were, more or less completely by the large intestine (*e f g h*, *fig.* 139.; *a t d*, *fig.* 155.). Its upper extremity (*j'*, *fig.* 161.), is continuous, without any line of separation, with the duodenum. The distinction between the two parts is established by the angle which the mesentery forms with the mesocolon, or rather by the point where the superior mesenteric vessels cross over the small intestine. Its lower extremity (*d*, *fig.* 139.; *i*, *fig.* 161.) enters at a right angle into the large intestine. The old division of the small intestine into the *jejunum* and *ileum* should be banished with other anatomical niceties, for it is founded only upon trivial distinctions; and although the upper part of this intestine differs in many respects from the lower, still the alteration takes place by imperceptible gradations.* So that Winslow, unable to find any real difference, established a purely conventional distinction, by proposing to call the upper two fifths the jejunum, and the lower three fifths the ileum.

Fig. 155.



No portion of the alimentary canal is so moveable as the small intestine, properly so called. It is exceedingly loosely attached, or, as it were, suspended from the vertebral column by a large fold of the peritoneum, called the *mesentery* (the attached portion of which is seen at *m*, *fig.* 161.), which, being broader in the middle than at either extremity, gives an unequal mobility to the different parts supported by it. The small intestine is displaced with great facility.

The circular boundary described around it by the large intestine, is only exact above, where the mesocolon and the arch of the colon (*t*, *fig.* 155.) completely separate it from the stomach (*s*), the liver (*l'*), the spleen (*k*), and the duodenum. But below, between the cæcum (*c*, *fig.* 161.) and the sigmoid flexure

* The upper part of the intestine is called *jejunum*, because it is generally found empty; the second *ileum*, either because it has been supposed chiefly to occupy the iliac regions, or on account of its convoluted disposition, which, however, is common to it with the other (εἰλεῖν, to turn, to twist).

of the colon (f), it descends into the pelvis, and, extending laterally, passes in front of the colon in both the right and left lumbar regions.

This excessive mobility is one of the most characteristic and important facts regarding the small intestine, which, in some measure, floats in the abdominal cavity, yielding to the slightest impulse or concussion. Of all the viscera it is the most frequently involved in hernia. It is liable to invagination, *i. e.* one portion may be received, as into a sheath, into that immediately succeeding it. When any organ in the abdomen becomes enlarged, the small intestine yields, and passes in the direction where there is least resistance. It appears to partake of the mobility of fluids. It collects together, or spreads out; it moulds itself upon the adjacent parts, and fills up every space, so as to elude all causes of compression; and by means of this admirable contrivance, the abdomen accommodates itself without inconvenience to the occasional enormous developement, either natural or diseased, of the organs contained within it.

Direction. We have seen that the upper or supra-diaphragmatic portion of the digestive canal is straight. The stomach presents one slight curve. The duodenum has two decided curves, and the rest of the small intestine pursues a not less flexuous course. The following is the direction of this intestine: commencing at the duodenum (j, *fig.* 161.), it passes forwards and tothe left side; it is then folded a great number of times upon itself, and, at its lower part, it passes transversely from the left to the right side, and a little upwards, in order to enter at a right angle (i) into the great intestine.

The numerous foldings or turnings (*gyri*) of the small intestine upon itself have received the name of *convolutions;* they are moulded upon each other, without intermixing or becoming entangled, so as to form a mass which so closely resembles the surface of the brain, that the term convolutions has also been applied to the winding eminences of that organ.

Each *convolution* represents an almost complete circle. In the complexity presented by the numerous windings of the small intestine, it appears to be very difficult to assign to it any general direction; nevertheless, if we consider that the small intestine commences to the left of the second lumbar vertebra, and terminates in the right iliac fossa, it will be seen that its general direction coincides with that of the membranous fold (m, *fig.* 161.), which supports it; that is, it may be expressed by an oblique line running downwards from the left to the right side. If, however, we examine the particular direction of the convolutions, we shall find that they all present a concavity towards the mesentery, and a convexity towards the parietes of the abdomen, so that each resembles the half of the figure 8. In consequence of this arrangement, the intestine may become folded without much change in its position, either in advance or otherwise; and hence the great number of folds which can be placed between two points so near each other as the left side of the second lumbar vertebra and the right iliac fossa, the distance between which is not more than four inches.

Dimensions. The determination of the *length* of the small intestine, properly so called, has at all times been a subject of interest. Meckel says that it varies from thirteen to twenty-seven feet, including the duodenum. According to my observations, it varies from ten to twenty-five feet in the adult.* The length of the small intestine, compared to that of the large intestine, is generally as five to one. The different results which have been obtained by various authors may be explained, partly by individual varieties, and partly by the mode in which the measurements were made. Thus, a more or less perfect separation of the gut from the membranous folds which support it would lead to different results. But another and less understood cause of difference is the influence of the caliber of the intestine upon its length. The caliber and the length have always an inverse ratio to each other. Of this we may be easily convinced, by strongly inflating a portion of gut which has been previously measured. I have

* The average length of the small intestine, including the duodenum, is 20 feet. I have lately measured several: in a female affected with chronic peritonitis it was only 7 feet long; in another 14; in a third 18; in a fourth 20; and in a fifth 22.

often been struck with the shortness of the small intestine in cases of hernia, accompanied with retention of the contents of the gut above the strangulation.

Some authors have attempted to establish a relation between the length of the intestine and the stature of the individual; and it has been affirmed, that the former is four or five times the height of the body. But differences in stature have not a uniform relation to the length of the alimentary canal.

Lastly, individual varieties in the length of the small intestine do not appear to have any influence upon the activity of the digestive process.

Caliber. The caliber of the small intestine, properly so called, is not the same throughout. It is greater at the commencement than at the termination of the intestine. When moderately distended by inflation, I have found it six inches and four lines in circumference at its commencement, four inches and two lines at the middle, and three inches and a half a little above its entrance into the large intestine; but at the point of entrance itself it is dilated to about four inches and a half.

The small intestine, therefore, is funnel-shaped — a form which must facilitate the rapid passage of its contents, by causing them to proceed from a wider into a narrower space.

Lastly, the caliber of the small intestine presents many varieties. When any obstruction occurs to the passage of its contents, it may attain the caliber of the large intestine. In certain cases of marasmus, when it contains no gases, it becomes so contracted that the tube is completely obliterated.

Figure and relations. The small intestine is cylindrical; a section of it is almost circular. Its *posterior border*, to which the mesentery is attached, is concave; it is thrown into slight folds, as every straight cylinder must be, when it is bent into a curve. Its *anterior border* is convex, free, and corresponds to the abdominal parietes, being separated from them by the great omentum *, which seems intended to contain the whole mass of the intestinal convolutions. When the omentum is wanting, as in the fœtus, or in cases of displacement from its being rolled up into a cord, the small intestine is in immediate contact with the parietes of the abdomen.

The *lateral surfaces* of the different convolutions of the small intestine are in contact with each other. As these surfaces are convex, they intercept triangular spaces before and after them, in which either effused blood, or serum, or pus, or false membranes, are sometimes collected.

The small intestine corresponds to all the regions of the abdomen, excepting those of the upper zone. Not uncommonly we find it escaped from under the omentum, and situated between the liver and the abdominal parietes, or reaching into the left hypochondrium. It is immediately forced, as it were, in any direction in which there may be an opening.†

More or less of the small intestine is always found in the pelvis; in the male between the bladder and the rectum, in the female between the bladder and the uterus, and between the uterus and the rectum. In several persons who were emaciated from chronic diseases, and in whom the vertebral column could be plainly felt through the parietes of the abdomen, I have found almost the whole, and, in some cases, even the whole, of the small intestine within the pelvis, contracted and almost entirely void of air. When one portion only of the small intestine is in the pelvis, it is invariably the lower part.

When any large mass is developed in the abdomen, as in pregnancy, or in encysted dropsy of the ovarium, the small intestine passes upwards and laterally, becomes diffused, fills up every space, and almost always escapes compression in the most remarkable manner.

It is not uncommon to find in the small intestine, appendices or diverticula, like the fingers of a glove, which are sometimes two or three inches in length,

* [In *fig.* 155. the great omentum has been removed.]

† The small intestine is found in diaphragmatic herniæ; it constitutes perineal hernia; and it is this portion of the bowels which escapes from the pelvis when the lower wall of that cavity is divided.

and have been found in the sacs of herniæ. These diverticula are usually much nearer the lower than the upper part of the small intestine. They are formed by all the coats of the bowel, and are very different from mere protrusion of the mucous membrane through the muscular coat, of which I have seen one example in the duodenum, and which I have often met with in other parts of the small intestine. In a subject which I recently examined, the small intestine presented about fifty spheroidal tumours, of unequal size, all situated along the mesenteric side of the gut, and formed by protrusions of the mucous membrane through the muscular fibres.

Structure of the Small Intestine.

Dissection. This structure must be studied upon a distended and moist portion of intestine, upon a distended and dried specimen, and also upon one inverted and distended. It is also of importance to study the mucous membrane under water, with the assistance of a strong lens. Injections thrown in first by the veins and then by the arteries, are also useful in developing its structure.*

The small intestine, as well as the stomach, is formed of four coats or membranes, which, proceeding from without inwards, are the *serous*, *muscular*, *fibrous*, and *mucous coats*.

The serous coat. The arrangement of this coat upon the duodenum differs from that upon the rest of the small intestine.

The peritoneum is applied to the first portion of the *duodenum* in the same way as upon the stomach, *i.e.* it covers it entirely, excepting in front and behind, where there is a triangular space devoid of this coat. Like the stomach, this first portion gives attachment to the great omentum in front, and to the small omentum behind. The fold of peritoneum which passes from the liver to the duodenum has been improperly called the *hepatic ligament of the duodenum*. The peritoneum merely passes over the front of the second and third portions of the duodenum, so that the posterior surface of the intestine is in immediate contact with the parts with which it is in relation, and is very perfectly fixed.

The peritoneum forms a complete sheath for the *small intestine*, properly so called, excepting along its concave border, where the two layers which constitute the mesentery separate from each other, so as to include the bowel. In this situation we find a triangular cellular space, exactly resembling those which we have already described along the curvatures of the stomach, and performing a similar office, viz. that of remedying the slight extensibility of the peritoneum, and permitting the intestine to undergo sudden dilatation to a great extent. We should have a very incorrect notion of the dilatability of the intestine if we imagined that it is limited by the triangular space along its concavity, for when the bowel is much distended, the mesentery itself becomes separated into its two layers to allow of such distension. Of this I am convinced, from having measured the antero-posterior diameter of the mesentery both before and after inflation of the bowels.

The cellular tissue which unites the peritoneal to the muscular coat is extremely delicate, and its adhesion to the latter coat increases in proceeding from the concave to the convex border of the intestine. Although the peritoneal coat is very thin, and so transparent that the muscular fibres may be seen through it, yet it has considerable strength.

The *muscular coat* is composed of two layers of involuntary muscular fibres, one superficial, the other deep. The *superficial layer* is the thinner; it consists of longitudinal fibres placed around the bowel in a very regular manner, and forming a continuous plane. I have never found these fibres more numerous at the mesenteric than at the convex border. This layer of fibres is almost always removed with the peritoneal coat, to which it adheres very intimately. From their white colour and shining appearance under the serous membrane, they have been supposed to be of a tendinous nature.

* The *internal surface of the small intestine* will be noticed with the mucous membrane.

It is difficult, though by no means important, to determine exactly whether the same fibres reach the whole length of the intestine, or whether they are interrupted at intervals. It is generally admitted that they are interrupted, and that their extremities are received in the spaces between other fibres.

The *deep layer* of muscular fibres is thicker than the preceding, and consists of circular fibres, either parallel or crossing each other at very acute angles. They appear to me to describe complete circles, and to have their ends united. They have no tendinous intersections.

The *fibrous coat* is intermediate between the muscular and mucous tunics, and presents the same characters as in the stomach.

The mucous or papillary membrane. Its *external surface* adheres to the fibrous membrane by a loose cellular tissue, which is liable to serous, sanguineous, and purulent infiltration. The emphysematous or œdematous condition may be imitated in the dead body, by everting a portion of bowel and distending it either with air or water. The tenuity of the mucous membrane displayed in these experiments has led to the opinion that this coat is nothing more than an epithelium, a continuation of the epidermis of the skin, and that the fibrous coat represents the cutaneous dermis. Its *internal surface* is free, and is covered with more or less mucus: it is remarkable for its duplicatures or valves, called *valvulæ conniventes*; for its highly developed *papillæ*, and for the arrangement of its *follicles*.

The Valvulæ Conniventes (*Valvulæ Intestinales*).

Dissection. Evert the small intestine, so that its external surface becomes internal, and then plunge it in water; or, what is better, lay open the bowel, and examine its internal surface under water. Also study a portion of intestine inflated and dried.

Hitherto the mucous membrane of the alimentary canal has only presented to our notice certain folds which are intended to facilitate the dilatation of that canal, as in the œsophagus and stomach, and which are completely effaced by distension. The folds of the mucous membrane of the small intestine fulfil another purpose; and although they must, undoubtedly, in some measure assist in the elongation and dilatation of the bowel, yet they are never entirely effaced, however far this extension in length or width may be carried. These folds deserve a special description. They are called *valvulæ conniventes* or the *valves of Kerkringius*, although Fallopius had given a complete description of them before that anatomist. Kerkringius gave them the name of conniventes (*conniveo*, to close partially). They commence in the duodenum (see *fig.* 169.), an inch or sometimes two inches from the pylorus; and it is not uncommon to find them preceded by some vertical folds. They are few and small at first, but become very numerous and very large towards the end of the duodenum and the commencement of the small intestine properly so called. From the upper two fifths of that intestine they gradually diminish in number, and become less regular and less marked towards the lower part of the small intestine; sometimes they are altogether wanting in the last two or three feet of the bowel. In some rare cases I have seen valvulæ conniventes as far down as the ileo-cæcal valve; in no part are they sufficiently numerous to have a true imbricated arrangement. These valves are placed perpendicularly to the axis of the intestine, and describe one half, two thirds, or three fourths of a circle; but they seldom form a complete ring. They are broader in the middle, being from two or three lines in width, than at their extremities, which are slender. In order to ascertain their dimensions, they must be placed under water, or studied upon a fresh portion of intestine. They are generally parallel, incline towards each other by their extremities, bifurcate, and send off small verticular oblique prolongations. Sometimes we find small valves placed between the larger ones. Some of them are suddenly interrupted so that they might be supposed, at first sight, to have undergone some loss of substance.

Several of them are alternate, and seem to be disposed in a spiral manner; but there is no general rule in this respect; their free edge is sometimes directed towards the pylorus and sometimes towards the ileo-cæcal valve. Their direction is very irregular; they yield to any impulse that may be communicated to them, and their free edge passes either upwards or downwards, according to circumstances. When examined upon a dried specimen, they resemble very much the diaphragms in optical instruments.

The valvulæ conniventes are formed by folds of mucous membrane, within which we find some loose cellular tissue, different kinds of vessels and nerves. Inflation, by raising the mucous membrane, completely effaces them. The fibrous coat presents a slight thickening opposite the bases of these valves. The valves, notwithstanding the ease with which they are moved, must in some manner retard the passage of the food, without offering any decided resistance to it, for that would become a cause of obstruction, and give rise to serious accidents. Their chief use, perhaps, is to increase the extent of surface: according to Fabricius they double the surface of the intestine, Fallopius says they increase it three times, and Kew six times. Sœmmering has given the somewhat conjectural opinion, that the surface of the intestinal mucous membrane is greater than that of the entire skin. (*Corpor. Hum. Fabrica*, t. vi. p. 295.) Although not peculiar to the human species, they are much more developed in man than in the lower animals.

Besides the valvulæ conniventes, the mucous membrane of the small intestine presents some *irregular folds*, which are effaced by distension.

The Papillæ, or Villi.

Preparation. 1. Place the opened intestine in water, exposing it to a strong light, and agitate the fluid. A stream of water previously received upon the membrane, will remove the mucus, which sometimes forms a tenacious sheath around each papilla.* 2. Roll up a portion of the detached mucous membrane, taking care to turn the adherent surface inwards. 3. Evert a loop of intestine, so that the peritoneal coat may be on the inside: stretch it upon a cylinder, and then agitate it in a cylindrical vessel, so as to float out the valves.

The *papillæ*, or *villi*, are much more developed in the small intestine than in any other part of the alimentary canal, with the exception of the tongue. Fallopius has the honour of having discovered them. They were well described by Helvetius, Hewson, and Lieberkuhn, but still more accurately of late by Albert Meckel. When examined by the naked eye and under the microscope, the internal surface of the intestine appears to be roughened by an immense number of prominences or villi (*figs.* 157. 159.), resembling very close short grass, or a very hairy caterpillar. In some animals, as in the dog, and especially in the bear, the villi are so numerous and so long, that they in some degree resemble the filamentous roots of plants. They are found through the whole length of the small intestine, and cover the valvulæ conniventes, as well as the intervals between them. They vary in *length*: according to Lieberkuhn, they are one fifth of a line; their maximum length appears to be about four fifths of a line: and I have even found some in the duodenum, which when extended were a line in length. Their *number* is very considerable, and attempts have been made to determine it. Lieberkuhn computed them at 500,000. Several Germans have taken up the subject; allowing 4000 to every square inch, by a calculation, the exactness of which I have not verified, there would be a million altogether. I have not observed any well-marked difference as regards the number of the villi, between the commencement and the termination of the small intestine. It appears to me that the number and length of the villi is much greater in carnivora than in herbivora. The otter has been said to have the largest villi of any animal. Their form varies much. In the majority of animals which I have examined, as the dog, cat, calf, and bear, they are filiform. In the

* A. Meckel recommends that the mucus should be removed by plunging the intestine first in an arsenical solution, and then in water impregnated with sulphuretted hydrogen; but the continued action of a stream of water is far preferable.

human subject they are all lamellar or foliaceous, but with many varieties. In the duodenum they are curved upon themselves, presenting the appearance of a calyx or corolla, and sometimes adhering to each other by their extremities. In the small intestine, properly so called (*figs.* 157. 159.), they are rectilinear, floating, cylindrical, conical, clubbed at the end, constricted, and sometimes bent in the middle. In the neighbourhood of ulcerations, they are, as it were, cut off close or truncated, without presenting any alteration in their structure.

Structure. Brunner calls them membranous tubes; Leeuwenhoek regarded them as muscular organs; Helvetius and Hewson considered them to be small valves, an idea which has been revived and carried out more lately by Albert Meckel. This anatomist, who has given representations of the villi in a great number of animals (*Journ. Complement*, t. vii. p. 209.), regards them as formed of small lamellæ, sometimes twisted upon their axes, like the first leaf of a germinating grain of wheat, and sometimes folded into a semi-canal or groove; but he considers that all these varieties may be referred to that of a lamella, broad at the base and narrow at the apex, a fundamental form which may always be demonstrated with the aid of a needle.*

Lieberkuhn states, that at the base of each villus there is an ampulla, which opens upon the summit of the villus by a single orifice; and he considers that both the ampulla and the orifice belong to the commencement of the lacteal vessels; arteries and veins ramify round the ampulla; and each villus has an afferent artery and an efferent vein. According to Mascagni, the villi are composed of an interlacement of bloodvessels and small lymphatics, and are covered by an extremely thin membrane, composed of lymphatics. The following are the results of my own observations. Having had occasion to examine a subject in which the lymphatic vessels were filled with tubercular matter, I was able to trace a lymphatic trunk into each villus (vide. *Anat. Path.* avec planches, liv. 2.), which traversed its entire length. This perfectly agrees with Lieberkuhn's account. In another subject I injected mercury into one of the mesenteric veins, and then above the mercury I forced in a coarse black injection. The mercury and a part of the black injection passed into the cavity of the intestine, and a globule of mercury appeared upon the summits of the villi, which were blackened from the injection. From this I have concluded that the villi are perforated at their summits. I shall return to this subject again.†

The duodenal glands and follicles. Preparation. Some intestines are not well adapted for the study of the follicles, which, indeed, seem to be entirely

* [Many of the villi are certainly cylindrical, and therefore not referrible to the fundamental form described by Albert Meckel. In the fœtus and young subject they are comparatively broader and flatter, and are connected at their bases so as to form folds having irregular margins. In this stage of their developement they resemble the rugæ in the intestines of birds and reptiles.]

† [The villi contain all the elements of the intestinal mucous membrane; no nerves, however, have been actually demonstrated in them.

Fig. 156.

The bloodvessels are numerous, and form a very beautiful capillary network in each villus (3, *fig.* 156.). Great differences of opinion have existed and still exist as to the mode of origin of the lacteals in the intestinal villi: the best authorities, however, agree in stating that they do *not* commence by *open* orifices. Rudolphi and A. Meckel considered that they arose by a *closed* network; Dr. Henlé found a single dilated but *closed* lacteal in each villosity; and more recently, Krause observed that in each villus the lacteal arose by several branches, some of which ended in free but *closed* extremities, whilst others anastomosed together (2, *fig.* 156.). The villi, and, it may be observed here, every portion of the intestinal mucous membrane are covered by a transparent columnar epithelium, consisting of elongated prismatic nucleated corpuscules. The perpendicular arrangement of these upon the surface of a villus, is shown in the diagram (1, *fig.* 156.).]

wanting in them. Others, again, are very favourable for that purpose. The follicles are rendered more apparent by plunging the intestine into acidulated water. They must be examined from the internal surface of the mucous membrane, and also from its external surface by removing the serous, muscular, and fibrous coats by which they are covered. In the study of the duodenal glands, this last method of investigation is absolutely necessary.

The *follicles* are generally divided into two kinds, the *simple* or *solitary* and the *agminated*; to these we shall add the *duodenal glands*.

The duodenal glands. These, properly speaking, are the *glands of Brunner*. This anatomist, who had already made some curious experiments upon the pancreas, says, that, having partially boiled the duodenum, he observed upon its internal membrane some granular bodies, which he has had figured, resembling the solitary follicles in the neighbouring portion of intestine. To this collection of granules he gave the name of the *second pancreas*. Further observations have shown, that in the upper half, or upper two thirds of the duodenum, there is a layer of flattened granular bodies, perfectly distinct from each other, however close they may be. This layer must not be confounded with the glandiform arrangement of the duodenal villi; it can only be well seen after having removed the three outer coats. These granular bodies are nothing more than small (compound) glands, which, when examined with a powerful lens, present all the characters of the salivary glands. These glands do not cease abruptly, but become few and scattered towards the lower end of the duodenum; so that it is by no means inconsistent to admit that the solitary follicles of the rest of the intestinal canal may be of a similar nature.*

The *solitary follicles*, or *glandulæ solitariæ*, are generally known in the present day as the glands of Brunner (*Disput. de Gland Duoden.* Heidelberg, 1687, 1715), although that anatomist only described the glands or follicles of the duodenum, which he said diminished in number below that portion of the intestine, and disappeared altogether in the jejunum. It is therefore by an extension of the author's meaning that we speak of the glands of Brunner as occupying the termination of the small intestine, the stomach, and even the large intestine.

The glandulæ solitariæ present the appearance of small rounded granulations, like millet seeds, projecting upon the internal surface of the mucous membrane, without any distinct orifice, and covered with villi (*fig.* 157.); they are found upon the valvulæ conniventes, as well as in the spaces between them. Their number is very considerable; so that in certain diseases where they become more prominent than usual, they might be mistaken for a confluent eruption. It is a mistake to say that they diminish in number from the upper towards the lower part of the small intestine, the contrary being nearer to the truth. When examined with the simple microscope, they have appeared to me to be hollow and filled with mucus.†

The *agminated follicles*, or *glandular plexuses*, are more generally known as the *glands of Peyer*, although both the solitary and agminated glands were described by that anatomist. Pechlin noticed them under the name of *vesicularum agmina*. Willis, Glisson, Malpighi, Duverney, and Wepfer have given more or less complete descriptions of them; but Peyer (*De Glandulis Intestinorum*. J. C. Peyer, 1667, 1673), when still a young man, and without any

Fig. 157.

Magnified.

* [According to Dr. Boehm (*De Gland. Intestin. Struct. penitiori*), this is not the case, the compound glands of Brunner not existing below the commencement of the jejunum.]

† [*Fig.* 157. is a solitary gland magnified; it is represented, after Boehm, as a *closed* vesicle, filled with whitish matter, which contains granules smaller than those of mucus. Villi are seen upon the free surface of its capsule, and it is surrounded by the crypts of Lieberkuhn (the mouths of which are indicated by the darker spots), which have no communication with the vesicle itself (see also note, p. 490.).]

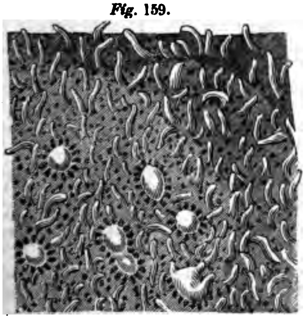
knowledge of the work of Pechlin, described and figured them under the title of *glandulæ agminatæ* so accurately as to leave nothing to be desired.

These agminated glands are arranged in elliptical patches (*fig.* 158.), the long diameter of which corresponds with the direction of the intestine: they are pierced with holes, or small depressions, so that they have a honeycombed appearance; and hence has arisen the name of *plaques gaufrées*, under which I believe I was the first to describe them: they are all situated on the border opposite to that by which the mesentery is attached to the intestine; that is, along the convex border of the intestine, and never along the concave border, nor even upon either side. They are chiefly found toward the end of the small intestine; they become more and more scattered as we approach the duodenum, in which, however, Peyer once met with a single patch. Their number varies considerably, twenty, thirty, and even more having been counted. Are they ever entirely wanting? The difficulty of detecting them in some subjects has led to their being rejected altogether, or considered as the results of a pathological condition; but this opinion is clearly at variance with observation. Again; these patches are not constant either in situation, form, or dimensions. Sometimes they assume the appearance of bands two or three inches in length (*fig.* 158.), and sometimes they form circular or irregular clusters. The largest are found near the ileo-cæcal valve. It is not rare to find the termination of the small intestine surrounded by a circular patch; in other cases, the patches terminate some inches above the ileo-cæcal valve, and their place is supplied by simple follicles.

Fig. 158.

These patches are generally contained in the substance of the mucous membrane, to which they give a much greater density, so that in these situations it will bear to be scraped. In some cases they appear to be imbedded in the fibrous coat. They should be examined both from the external and internal surfaces of the mucous membrane.* When they are filled with their secreted fluid, and are examined by transmitted light, they may be compared to the vesicles in the skin of an orange: this observation may be easily made in the day. They evidently consist of collections of glands, exactly resembling the solitary glands (*fig.* 159.). Each depression appears to be the orifice of one of the follicles, which are quite independent of each other; so that we sometimes find two or three altered in the middle of a patch, which is otherwise perfectly healthy. Lastly, villi are found upon the patches of the glandulæ agminatæ: they occupy the intervals between the depressions.†

Fig. 159.



Magnified.

* [Their contents are sometimes transparent, and they are then very difficult of detection.]

† [In *fig.* 159., representing part of a patch of Peyer's glands magnified, are seen some of the

The follicles or corpuscules of Lieberkuhn. Lieberkuhn speaks also of innumerable, rounded, whitish follicles which are seen between the villi, and of corpuscules which are visible between these follicles. He calculates that there are eighty follicles for eighteen villi, and eight corpuscules for each follicle. I am disposed to think that these follicles and corpuscules, which have never been seen excepting by the microscope, should be referred to those globules which are revealed in all the tissues by the aid of a magnifying power.*

The vessels and nerves. All the *arteries* of the small intestine properly so called are branches of the superior mesenteric. They are very numerous. Those of the duodenum arise from the hepatic. The branches from the superior mesenteric are remarkable, for the numerous anastomotic loops which they form before reaching the intestine, for their flexuous course within its coats, and for the series of vascular layers formed by them between the peritoneal and muscular, the muscular and fibrous, and the fibrous and mucous coats. The last layer forms a very complicated network, from which the vessels of the mucous membrane are derived. The *veins* are much larger than the arteries, and present a similar arrangement, except in regard to the flexuous course, which is peculiar to the arteries; they constitute the superior mesenteric vein, which is one of the principal branches that contribute to form the vena portæ.

The *lymphatic vessels* are of two kinds, viz. lacteals and lymphatics properly so called; they both enter the numerous lymphatic glands, situated in the mesentery; those which belong to the duodenum enter the glands above the pancreas.

The *nerves* are derived from the solar plexus.

The *developement* of the small intestine will be noticed in conjunction with that of the large intestine.

Uses. Chylification, *i. e.* the transformation of the chyme into chyle, is effected in the duodenal portion of the small intestine. The essential agents of this process are the bile and the pancreatic fluid. In the remainder of the small intestine (the jejunum and ileum), the absorption of the chyle takes place. The numerous convolutions, the valvulæ conniventes, and the villi, all tend to increase the extent of the absorbing surface. The products of exhalation and of follicular secretion serve to complete the digestive process. The contents of the bowels are forced along by the shortening of the longitudinal, and the contraction of the circular fibres, the latter producing the vermicular motion of the intestines.

The Large Intestine.

The *large intestine* is that part of the alimentary canal which extends from the end of the small intestine (*d, fig.* 139.) to the anus (*i*). It commences in the right iliac region (*c, fig.* 161.), and passes upwards (*a*) as far as the right hypochondrium; then having reached the liver, it makes a sharp flexure (the *right or hepatic flexure*), and proceeds transversely (*t*) from the right to the left side (*transverse arch of the colon*); in the left hypochondrium, below the spleen, it again makes a sharp bend and becomes vertical (*d*), (*left or splenic flexure*).

elevated white bodies described by Boehm as resembling the solitary glands, except in not generally having any villi situated directly upon them. Each is surrounded by a zone of dark points, the elongated openings of the crypts of Lieberkuhn. Many of these crypts are also seen scattered irregularly between the numerous villi; none of them communicate with the interior of the whitish bodies, in which, whether solitary or agminated, Boehm could discover no opening, at least not in a healthy human intestine. He considers them, therefore, to be *closed* vesicles, not follicles.

More recently, however, Krause has observed that in the pig's intestine they are occasionally open, independently of disease; and Dr. Allen Thomson has lately made a similar observation in reference both to the pig and to the human subject.]

* [The follicles, or crypts of Lieberkuhn, are tubes placed more or less perpendicularly to the surface of the mucous membrane, like those in the stomach, but situated more widely apart; their open mouths are seen scattered over the whole surface of the membrane, or collected around the solitary and agminated glands (*figs.* 157. 159.). The *corpuscules* (*corpora albicantia*), described by the same observer as being situated in the bottom of the crypts, are probably collections of desquamated epithelium within them.]

In the left iliac region (*f*) it is twice bent upon itself, like the Roman letter S (*iliac or sigmoid flexure*), and it then dips into the pelvis (*r*), and terminates at the anus.

The large intestine, therefore, describes within the abdomen a nearly complete circle, which surrounds the mass of convolutions of the small intestine; and it occupies the right and left iliac regions, the right and left lumbar, the base of each hypochondriac, and the adjacent borders of the epigastric and umbilical regions. Although it is much more firmly fixed in its place than the small intestine, and is therefore less liable to displacement, yet it presents some varieties in length and curvature which have a considerable influence over its position. The large intestine is more deeply situated than the small in one part of its extent, but in another is at least quite as superficial.

From its long course, and from the different relations presented by its different parts, it has been divided into the *cæcum*, the *colon*, which is itself subdivided into several parts, and the *rectum*.

Dimensions. The *length* of the large intestine is four or five feet, and, compared with the small intestine, is as one to four; but it varies considerably, rather, it would seem to me, from the effects of repeated distension, than from any original conformation; for it may be easily imagined that the bowel cannot be distended transversely without losing somewhat in length, and that on returning to its former diameter it must be elongated in proportion to the distension it had previously undergone. The large intestine has also generally appeared to me longer in persons advanced in age than in adults.

Its *caliber* or diameter usually exceeds that of the small intestine, but may become so reduced, that the gut resembles a hard cord about the size of the little finger. In other cases it is so large, that it occupies the greatest part of the abdominal cavity: this is observed in tympanitic distension of the large intestine. It is not of uniform caliber throughout, as the following measurements will show. The circumference of the cæcum, moderately distended, and taken immediately below the ileo-cæcal valve, was found to be eleven inches and there lines in one subject, and nine inches and a half in another; the right colon in the loins and the right half of the arch were eight inches and nine lines in the first, and five inches some lines in the second subject. The circumference of the left half of the arch of the colon, and of the left lumbar colon was six inches in the first and five inches and a half in the second. The circumference of the sigmoid flexure was five inches and a quarter; that of the rectum was three inches until near its termination, where it presented a dilatation four inches in circumference in one, and five inches in the other subject.

It follows, therefore, that the large intestine, like the small, has an infundibuliform shape; it resembles, indeed, two funnels, the base of the one corresponding to the cæcum, and its apex to the sigmoid flexure, whilst the base of the other is at the dilated portion of the rectum, and its apex is applied to that of the first. It is probable that this infundibuliform arrangement has some reference to the passage of the fæcal matters.

It also follows that there is no uniform relation between the diameters of the different portions of the large intestine: thus a very large cæcum and ascending colon may co-exist with a small descending colon. In some cases we find in the large intestine considerable dilatations, separated from each other by such constrictions, that the caliber of the corresponding part of the gut is obliterated. These strangulations from a contraction of the circular fibres are very different from those produced by organic diseases; they probably take place during life, and may account for the affection known as the windy colic. In some chronic diseases, accompanied with diarrhœa, the large intestine, contracted and containing no gases, is not as large as the small intestine.

The cæcum. The cæcum (*e*, *fig.* 139.), so named, because it resembles a cul-de-sac, is the first part of the large intestine. The existence of a cæcum is one of the numerous indications of the line of separation between the large

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... sometimes the small intestine is inserted at a right angle;
... angle of incidence is obtuse above, and acute below (*fig.* 160.

and the small intestine. Its upper boundary is altogether arbitrary; it is determined by a horizontal plane intersecting it, immediately above the insertion of the small intestine. It is single in the human subject, but is double in some species of animals. It is *situated* (*c*, *fig.* 161.) in the right iliac fossa, and occupies it almost entirely. It is one of the most fixed portions of the alimentary canal, for the peritoneum merely passes in front of it, and binds it down into the iliac fossa. It is not, however, so firmly fixed in all subjects; it is often enveloped by the peritoneum on all sides, and floats, as it were, in the region which it occupies, its capability of motion depending on the looseness of the right lumbar mesocolon. This arrangement of the peritoneum is not necessary, however, to explain the great amount of displacement which the cæcum undergoes in certain cases. It is not uncommon to find it in the cavity of the pelvis: it occasionally enters into the formation of herniæ, and, what is somewhat remarkable, it has been at least as frequently found in herniæ upon the left, as upon the right side.

Its *direction*, which is in general the same as that of the ascending colon, is not always vertical, as may be seen by examining a moderately distended intestine, but it passes obliquely upwards and to the right side, so that it forms with the colon an obtuse angle projecting on the right side; and I have even seen it form a right angle with the colon. This arrangement, connected with the obliquity of the plane of the iliac fossa, explains why, when its attachments are relaxed, it has less tendency to be displaced towards the right inguinal ring and femoral arch, than to the same parts on the left side. In some subjects, the cæcum and its vermiform appendix are applied to the lower part of the small intestine, so that the cæcum and the neighbouring part of the colon describe a curve, the concavity of which embraces the lower end of the ileum.

In *size* it is generally larger than the portion of intestine which succeeds it: this perhaps depends less upon its primitive conformation, than upon the accumulation of fæcal matters resulting from the inclined position of this intestine, and from the direction in which its contents are moved. It may be said as a general rule, that, next to the stomach, the cæcum is the largest part of the alimentary canal. There are many individual varieties in the length and capacity of this intestine, in which the fæcal matters are liable to be retained. These accumulations occasion great pain; they have been much studied lately, and have been often mistaken for inflammations. The cæcum is very slightly developed in carnivora, but, on the other hand, it is very large in herbivora.

Figure. The cæcum is a sort of rounded ampulla, all the diameters of which are nearly equal; it is also sacculated like the rest of the large intestine. Upon it we observe the commencement of the three longitudinal bands, which I have already noticed: of these the anterior is, in the cæcum, twice as broad as either of the two posterior; some folds of peritoneum loaded with fat, which are called fatty appendages (*appendices epiploicæ*); and, lastly, some protuberances, separated by parallel depressions, an arrangement which exists in the colon also, and is produced by the longitudinal bands.

Relations. In front, the cæcum is in relation with the abdominal parietes, through which it can be felt when it is distended with gases, or fæcal matters. When the cæcum is collapsed, the small intestine is often interposed between it and the parietes of the abdomen.

Behind, it rests upon the iliacus muscle, from which it is separated by the lumbo-iliac fascia. The cellular tissue uniting it to this aponeurosis is extremely loose, and therefore offers no opposition to displacement of the intestine. When the peritoneum forms a complete covering for the cæcum, that intestine is of course in indirect relation with the iliacus. The vermiform appendix is often turned back behind the cæcum. On *the inside*, the cæcum receives the small intestine; the angle at which they unite (the ileo-cæcal angle) varies much. Sometimes the small intestine is inserted at a right angle; most commonly the angle of incidence is obtuse above, and acute below (*fig.* 160.). Sometimes the

ileum, instead of passing upwards, is directed downwards, and then the angle of incidence is changed. A circular depression indicates the limit between the two intestines. *Below*, upon the free extremity or cul-de-sac of the cæcum, is seen the vermiform appendix (v), situated behind and on the left side, a few lines below the ileo-cæcal angle.

The arrangement of the *internal*, or *mucous surface* of the cæcum, is in accordance with that of its external surface: thus, three projecting ridges correspond with the three longitudinal bands; some cavities or pouches with the protuberances; and some transverse projecting folds forming incomplete septa, which are easily seen in a dried specimen, correspond with the parallel depressions. Upon this surface, to the left and a little behind, we also find the ileo-cæcal valve (a b, *fig.* 160.), and the orifice (o) of the vermiform appendix (v).

The ileo-cæcal valve. This is also called the *valve of Bauhin*, from the name of the anatomist to whom its discovery is attributed, although it had been described before his time. To obtain a perfect knowledge of it, it should be examined upon a fresh specimen under water, and also upon an inflated and dried intestine.

In a fresh specimen, when viewed from the cæcum, it presents the appearance of a projecting cushion, oblong from before backwards, and fissured in the same direction. It is a membranous and moveable cushion, and was incorrectly compared by Riolanus to the pyloric ring. It has two lips and two commissures; the two lips are in contact, except during the passage of the contents of the bowels. Two folds, proceeding from the two commissures, one of which is anterior and the other posterior, are lost upon the corresponding surfaces of the intestine. The posterior fold is much longer than the anterior; Morgagni called them the *fræna* of the valve. When viewed from the ileum it presents the appearance of a funnel-shaped cavity directed upwards, and to the right side.

In a *dried intestine*, the ileo-cæcal valve is seen to consist of two prominent valvular segments, projecting into the cæcum, so as to form an angular ridge. The upper or *ileo-colic* segment (b, *fig.* 160.) is horizontal; the lower, or *ileo-cæcal* (a), forms an inclined plane of about 45°, and both are parabolic. The upper segment is fixed by its adherent convex border, to the semicircular line, along which the upper part of the tube of the ileum is united with the colon; the adherent border of the lower segment, which is also convex, is continuous with the semicircular line of junction between the lower half of the ileum and the cæcum. The free borders of the segments are directed towards the right side, and are semilunar; they are united at their extremities, but in the middle leave between them (between a and b) an opening like a button-hole, which becomes narrower as the intestine is more distended. The diameter of this opening is in proportion to that of the small intestine. The free border of the lower segment is more concave than that of the upper. When examined from the ileum, the valve presents an angular excavation, exactly corresponding to the projecting edge found in the cavity of the large intestine. The lower surface of the upper valvular segment is slightly concave; the corresponding surface of the lower segment is slightly convex.

Fig. 160.

This double ileo-cæcal valve differs widely from the ring of the pylorus; it offers no obstruction to the passage of the contents of the small into the large intestine; but in ordinary cases it will not permit their regurgitation from the latter into the former. The lower or ileo-cæcal segment is elevated so as to prevent reflux from the cæcum, and the ileo-colic segment becomes depressed and opposes any return of the contents of the colon. Still, from a great number of experiments which I have performed on this subject, I am satisfied, that both water and air injected into the large intestine most frequently overcome the

resistance offered by this valve, though with different degrees of facility in different subjects. This regurgitation, however, only takes place with gaseous or liquid matters; such as have a greater degree of consistence cannot pass back, and therefore the reflux of fæcal matter is impossible.*

Structure. The structure of the ileo-cæcal valve was perfectly demonstrated by Albinus. If we follow his example and remove the peritoneal coat from a distended intestine, at the point where the ileum enters the large bowel, we shall at once perceive most distinctly, that the small intestine seems to sink in there; and if by means of careful and gradual force we attempt to disengage it from the large intestine, it may be drawn out, as it were, from the colon to the length of an inch or an inch and a half; and then, on inspecting the inside of the large intestine, we shall find that the valve has altogether disappeared, and that the ileum communicates with the cæcum and colon by a large aperture.

The precise *structure* of the valve is as follows: — it is composed of the circular muscular fibres of the ileum, which are prolonged as far as its free edge †; of the fibrous coat, and of the mucous membrane. A similar fact has been observed regarding this mucous membrane to one we have already several times noticed in describing the alimentary canal, viz. a sudden change in its character opposite the free margin of the valve. That portion of the membrane which lines the surface turned towards the large intestine has all the characters of the mucous membrane of that bowel, while that lining the surface directed towards the ileum has those of the mucous membrane of the small intestine. The limit between them is generally observed in diseases.

The appendix vermiformis. The appendix vermiformis (*v, figs.* 139. 160, 161.), so named from its resemblance to an earth-worm, commences at the posterior lower and left portion of the cæcum, of which it may be considered an appendage (*the cæcal appendix*); it resembles a small, hollow, and very narrow cord (*duodecies nascente colo angustior* says Haller). In *length* and in *direction* it presents much variation: its length is from one to six inches. It is somewhat wider at its point of junction with the cæcum, than in any other part, and is in general about the diameter of a goose-quill.

Its *direction* is sometimes vertically downwards, sometimes upwards, and often tortuous. I have found it spiral, and at other times contained in the substance of the mesentery, parallel to the ileum, and only free at its extremity. In some subjects it is funnel-shaped, widening out to become continuous with the cæcum, which, in such cases, is very narrow. Its *situation* and *relations* are equally variable. Thus, most commonly, it occupies the right iliac fossa, near the brim of the pelvis: it is attached to the cæcum and to the iliac fossa by a triangular or falciform fold of the peritoneum, which extends only to one half of its length, and allows it a greater or less capability of movement. It is still more moveable when it is entirely surrounded by the peritoneum, and has no mesentery. From this it may be conceived, that it may enter into the formation of herniæ, and may be twisted around a knuckle of the small intestine so as to cause strangulation. It is often turned back behind the ascending colon, between that intestine and the kidney: in one case of this kind I found the free extremity of the appendix in contact with the lower surface of the liver. I have also once seen it turned up behind the lower end of

* Nevertheless, if we consider that the large intestine must always be very much distended in order to produce a reflux of gases and liquids, it may be questioned whether the passage of gaseous or liquid matters from the large to the small intestine can take place during life. I have been able to determine the mechanism of the resistance offered by the valve from the effects of distension. The two segments are turned back, the lower one upwards, and the upper one downwards; their corresponding surfaces become convex, and they are pressed together the more and more forcibly in proportion to the amount of distension. In some subjects distension may be carried so far as to rupture the longitudinal bands, and yet not overcome the obstacle. In most cases the free edge of the lower segment glides from right to left under the upper one, which remains immoveable; and the gas and liquids escape with more or less facility, according to the degree of disturbance in the parts.

† [The longitudinal muscular fibres and the peritoneal coat pass directly from the small to the large intestine, without entering into the formation of the valve.]

the small intestine, and at another time embracing that bowel in front. None of these differences, however, depend on the situation of its point of attachment to the cæcum, which is always on the left side, below and behind the cul-de-sac, at a short distance from the ileo-cæcal valve.

When divided lengthwise, the cavity within it is seen to be so narrow that the walls are always in contact. A small quantity of mucus is found in it, and it often contains small scybala; cherry-stones and shot have also been found in it. The whole of its internal surface has a honeycomb appearance, like that at the lower end of the small intestine.* A valve of different size in different subjects, but never sufficiently large to cover the orifice entirely, is found at the point (*o, fig.* 160.) where the appendix communicates with the cæcum. The cavity of the appendix, like the cæcum, terminates below in a cul-de-sac; and in this, which is extremely narrow, foreign bodies may be lodged, and may then sometimes become the cause of those spontaneous perforations which are occasionally seen. The uses of this appendix are altogether unknown; in the human subject it is merely a vestige of an important part in many animals. Haller says that he has twice seen the vermiform appendix obliterated, *i. e.* without any cavity. I presume that this was the effect of morbid adhesion. Lastly, I once found this appendix as large as the index finger, and two inches in length; its cavity contained some thick transparent mucus. The orifice by which it should have communicated with the cæcum was obliterated.

The colon. The colon (*κωλύω, to impede; d f g h, fig.* 139.) constitutes almost the whole of the large intestine. It extends from the cæcum to the rectum, and, as we have already seen, there is no line of demarcation between these different parts. In the first part of its course it ascends vertically, then becomes transverse, next descends vertically, and is then curved like the Roman letter S, and becomes continuous with the rectum. From this long course, and also from its direction and numerous relations, the colon has been divided into four portions, viz. the *ascending* or *right lumbar colon*, the *transverse colon* or *arch of the colon*, the *descending* or *left lumbar colon*, and the *iliac colon* or *sigmoid flexure.* Each of these parts requires a separate description, at least with regard to its relations. Let us first point out the general form of the colon.

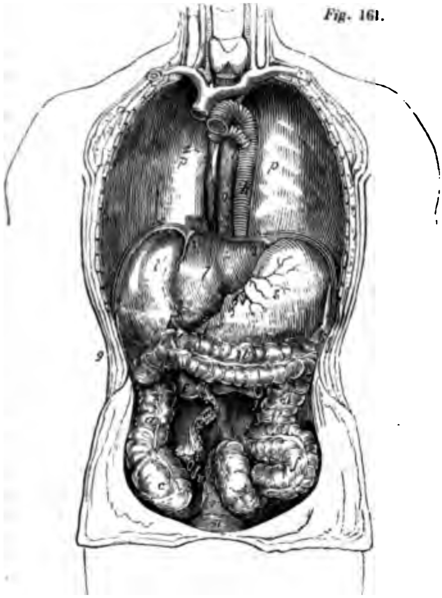
The colon presents a sacculated appearance throughout, which gives it some resemblance to a chemical apparatus, consisting of a long series of aludels. The sacculi of the colon are arranged in three longitudinal rows, separated by three muscular bands. Each of these rows presents a succession of enlargements and constrictions, or deep grooves, placed across the length of the intestine. These enlargements and grooves are produced by the longitudinal bands, which being much shorter than the intestine, cause it to be folded inwards upon itself at intervals. It follows, therefore, that division of these bands by means of a bistoury, or rather their rupture, from great distension of the gut, should destroy this sacculated appearance, and such, indeed, is the result of the experiment; at the same time, the large intestine becomes twice or three times as long as it was before, and forms a regular cylinder, like the small intestine. An incontestable proof of the relation between the cells of the colon and the muscular bands, is the concurrent absence of both in a great number of animals. Lastly, the three rows of sacculi vary much in different subjects, and also in different parts of the great intestine. The descending colon and the sigmoid flexure have only two rows of sacculi, and consequently two intermediate bands. The sacculi almost entirely disappear in the sigmoid flexure.

The ascending or right lumbar colon (*a, figs.* 155. 161.). This portion of the colon is bounded below by the cæcum, and above by the transverse arch, with which it forms a right angle, near the gall bladder. It is more or less firmly held in its place by the peritoneum, which in some subjects merely passes in

* [Nevertheless, the structure of the mucous membrane in the two situations is very different (see notes, p. 490. 502.).]

front of it, and in others forms a fold or lumbar mesocolon. The ascending and descending colon may be included among the most fixed portions of the alimentary canal. *In front* of it are the parietes of the abdomen, from which, excepting when greatly distended, it is separated by the convolutions of the small intestine. *Behind*, it is in immediate relation with the quadratus lumborum and the right kidney, no layer of peritoneum intervening. It is united to these parts externally by loose cellular tissue. This relation accounts for the bursting of abscesses of the kidney into the colon, and explains the possibility of reaching the colon in the lumbar region, without wounding the peritoneum. On the left side, advantage has been taken of this fact in attempting to form an artificial anus.

Fig. 161.



On the inside and on the outside it is in relation with the convolutions of the small intestine; and on the inside also with the psoas muscle, and with the second portion of the duodenum.

The transverse colon, or arch of the colon. This (*t*) is the longest portion of the large intestine; it extends from the ascending to the descending colon, from the right to the left hypochondrium, and generally occupies the adjacent borders of the epigastric and umbilical regions. It is not unfrequently found opposite the umbilicus, and even in the hypogastrium. Its right extremity corresponds to the gall bladder (*g*), its left is below the spleen (*k*). It describes a curve having its convexity directed forwards, and its concavity backwards; hence the name, *arch of the colon.* In some subjects it is two or three times its ordinary length, and hence it presents various inflections. I have seen its middle portion descending as low as the umbilical or hypogastric region, and even reaching the brim of the pelvis: in other cases it descends parallel to, and on the inner side of, the ascending colon, and then passes upwards again, or it describes curves of different extent. The arch of the colon is supported by a very remarkable fold of peritoneum, called the *transverse mesocolon*, which forms a horizontal septum between the small intestine below, and the stomach, the liver, and the spleen above. The extent of this fold, which is one of the largest of all those formed by the peritoneum, explains the great freedom of the movements of the transverse colon, which, next to the small intestine, is the part of the alimentary canal most frequently found in hernia.

Relations. Above, it has relations with the liver (*l*), which generally presents a slight depression, corresponding to the angle formed by the ascending and transverse colon; with the gall bladder (*g*), whence the discolouration of the right extremity of the arch from the bile: it is not rare to find the gall

bladder opening into the colon; with the stomach (*s*), which projects in front of it when distended, but is separated from it by a considerable interval when empty; and lastly, with the lower extremity of the spleen. (*k*) The two anterior layers of the great omentum, which proceed from the greater curvature of the stomach, pass over the arch of the colon without adhering to it. I have seen a large loop of the arch of the colon interposed between the liver and the diaphragm. *Below*, the arch of the colon corresponds to the convolutions of the small intestine (*fig.* 155.). *In front*, it corresponds to the parietes of the abdomen, beneath which it may sometimes be felt when distended with gas. It is separated from them by the two anterior layers of the great omentum. The two posterior layers of the great omentum are given off from the middle of its anterior border. *Behind*, it gives attachment to the transverse mesocolon.

The descending or left lumbar colon. The descending colon (*d*, *figs.* 155. 161.) so closely resembles the ascending portion, both in situation and relations, that we can only refer to what has been already stated. We must observe, however, that it is more deeply situated above than the ascending colon, and that it is of less size. Advantage has been taken of its immediate relations behind, with the quadratus lumborum, in the operation for artificial anus in cases of imperforate rectum. It is preferred for this purpose to the ascending colon, simply from its proximity to the anus.

The iliac portion, or sigmoid flexure, of the colon. The sigmoid flexure of the colon (*f*, *figs.* 155. 161.) is situated in the left iliac fossa, and is continuous below with the rectum. The line of demarcation between it and the descending colon is determined by the commencement of a fold of peritoneum, called the iliac mesocolon, or rather by the change in the direction of the large intestine, as it appears to detach itself from the parietes of the abdomen, opposite the crest of the ilium. It is continuous with the rectum at the point where it dips into the pelvis, opposite the left sacro-iliac symphysis. But, as it often happens that the lower portion, or even the whole, of the sigmoid flexure is contained in the cavity of the pelvis, it may be understood that such a definition is not precise.

It is retained in its place by a very loose fold of peritoneum, called the *iliac mesocolon*, and therefore, in some measure, partakes of the mobility of the small intestine. It has been found in almost all the regions of the abdomen, but especially in the sub-umbilical zone. It has been seen in the umbilical region, its first curvature reaching even to the liver. I have met with a case in which the sigmoid flexure extended upwards, and the arch of the colon downwards to the umbilicus, so that they came in contact with each other; the large intestine, therefore, corresponded with the whole anterior region of the abdomen, the sigmoid flexure alone occupying the umbilical, the hypogastric, and the left iliac region.

Should the following disposition, which I have met with several times, be regarded as accidental or congenital? Commencing from the descending colon, the sigmoid flexure passed transversely from the left to the right side, on a level with the brim of the pelvis as far as the right iliac fossa, below the cæcum, which it turned upwards in one case, and pushed in front of itself in another; the sigmoid flexure then described its two curves either in the right iliac fossa, or in the pelvis. These cases, in which the sigmoid flexure of the colon alone is transposed, must be carefully distinguished from general transposition of the viscera.

The most peculiar character of the sigmoid flexure is its *direction*. It passes, at first upwards, in an opposite direction to the descending colon, then descends vertically, and then curving again, passes to the right or to the left, forwards or backwards, and becomes continuous with the rectum (*r*), (the *iliac flexure*). These several flexures, however, vary exceedingly: I have seen them very slight; but then the upper or free portion of the rectum was found decidedly flexuous; and, indeed, it is difficult to ascertain whether such flexures belong

to the rectum, or to the displaced sigmoid flexure. There can be no doubt that this double curve of the colon is connected with its uses as a receptacle for fæcal matters.

The *size* of the sigmoid flexure varies considerably. In a case of imperforate anus in an infant, which lived twenty days, it became enormously distended. Retention of the fæces in the adult seldom causes so proportionally great an accumulation in the sigmoid flexure: the rectum is almost entirely the seat of the accumulation.

Relations. The sigmoid flexure corresponds to the abdominal parietes *in front.* When empty, its relations with the latter are indirect, in consequence of the interposition of some convolutions of the small intestine; when it is distended, they are immediate; and hence we are recommended to make an artificial anus in the sigmoid flexure of the colon, in cases where the rectum is imperforate. It is in contact *behind* with the iliac fossa, to which it is fixed by the mesocolon: hence it can be easily compressed and explored by the fingers, for the purpose of detecting hardened masses of fæces. In the rest of its circumference it is in relation with the convolutions of the small intestine.

The internal surface of the colon. On the internal surface of the colon are seen three longitudinal ridges, corresponding to the three muscular bands on its external surface; three intermediate rows of sacculi, the concavities of which agree exactly with the protuberances on the external surface; and lastly, numerous ridges or incomplete septa, dividing the cells of each row from one another, and improperly called *valves;* they correspond to the grooves or depressions on the external surface. In order to comprehend the arrangement of the cells and the intervening septa, we must examine the large intestine, when moderately distended and dried. If the muscular bands have been previously divided, the cells and septa disappear.

The internal sacculi, as well as the external protuberances, vary much in different individuals, and even in different parts of the same colon. Thus, there are generally only two rows in the descending colon and the sigmoid flexure, because there are only two muscular bands in those parts. Sometimes, indeed, there are no cells in the sigmoid flexure. Lastly, the internal surface of the large intestine presents some irregular folds, which are completely effaced by distension.

The rectum. The rectum (*h i, fig.* 139.), so called from its direction, which is generally less flexuous than that of the rest of the intestinal canal, is the last portion of the large intestine, and consequently of the digestive tube. It commences at the base of the sacrum, and terminates at the anus. It is *situated* in the true pelvis in front of the sacrum and coccyx (*r, fig.* 161.; *o o', fig.* 181.).

We see then that the alimentary canal, after having abandoned the vertebral column in order to describe its numerous convolutions, is situated at its termination in front of the lower part of that column, just as, at its commencement, it is applied to the upper part of the same. It is firmly fixed, especially below, where it is surrounded on all sides by cellular tissue, and is also bound down by the superior pelvic fascia. This part of it cannot, therefore, suffer such displacements as occur in hernia; but from its functions as an organ of expulsion, the whole effort of the abdominal muscles is concentrated upon it, and it is, therefore, liable to displacements of a different kind, viz. to invagination and eversion.

Its situation, which is in some degree constant, within a bony cavity, having unyielding walls, and its relations with the pelvic fascia, place it in conditions altogether peculiar to itself; for while the bladder and the uterus, which are also contained in the same cavity, ascend into the abdomen when they are distended, the rectum, in which the fæces are accumulated, dilates entirely within the pelvis, and undergoes no change of position.

From this fixed condition of the rectum along the middle of the pelvic cavity it also follows, that, in cases where the gut is denuded by destruction of the surrounding cellular tissue, it remains separate from the walls of the pelvis: such is the nature of fistulæ; and hence the necessity of cutting the rectum in order to bring it in contact with the walls of the pelvis.

Direction. Particular attention should be paid to the direction of this bowel, as an anatomical fact from which practical inductions of the greatest interest may be derived. It is not straight, but is curved both in the antero-posterior and lateral directions.

In the *antero-posterior direction* it follows the curve of the sacrum and coccyx, to which it is closely applied; it is, therefore, concave in front and convex behind (see *fig.* 181.). Opposite the apex of the coccyx it bends slightly backwards, so as to terminate about an inch in front of that bone. By this very remarkable inflection, it is separated from the vagina in the female, and from the urethra in the male.

The lateral inclination. On the left side of the base of the sacrum, and opposite the sacro-iliac symphysis, the rectum passes downwards, and to the right side, until it reaches the median line opposite the third piece of the sacrum. It then passes forwards, still in the median line, and forms a slight curve with the preceding portion. It has been frequently said that the lower part of the rectum does not occupy exactly the median line, but deviates a little to the right: this is not unfrequently the case at the lower part of the sacrum, but it always regains its original position before its termination.

There are, however, some important varieties in the curvature described by the rectum. Thus, it is not uncommon to see the upper part of the gut twisted like an italic *S* before reaching the median line; and in this case it is difficult to determine whether the twisted portion belongs to the rectum, or to the sigmoid flexure of the colon. In several of the cases of unnatural position of the sigmoid flexure, which I have already mentioned, the rectum commenced on the right side of the base of the sacrum, and passed downwards, and towards the left side. In one case, where the sigmoid flexure was in its natural position, the rectum passed almost transversely to the right side, as far as the right sacro-iliac symphysis, and then proceeded very obliquely to the left side. The situation of the upper part of the rectum on the left of the median line, has been often quoted in explanation of the relative frequency of inclinations of the uterus to the right side, and also of the greater or less amount of difficulty in parturition, according as the occiput of the fœtus is turned towards the right or the left.

Form and size. The rectum is cylindrical, not sacculated, and has no bands like those observed in the other portions of the large intestine. Its external surface is covered with a uniform layer of well-marked, fasciculated, longitudinal fibres, which give it some resemblance to the œsophagus. At its commencement, its caliber is somewhat smaller than that of the sigmoid flexure, but it gradually increases towards the lower end. Immediately before its termination at the contracted orifice, called the anus, the rectum presents a considerable dilatation, or ampulla, capable of acquiring an enormous size; so that, in certain cases of retention of the fæces, it has been found occupying the entire cavity of the pelvis.

Relations. Behind, the rectum corresponds with the left sacro-iliac symphysis and the curve of the sacrum and coccyx; it is attached to the sacrum above by means of a fold of peritoneum, called the *meso-rectum,* and is separated from the sacrum and the sacro-iliac symphysis by the pyriformis muscle, the sacral plexus of nerves, and the hypogastric vessels. Those portions of the rectum which project laterally beyond the coccyx are in relation with the levator ani muscles, which form a sort of floor for it.

In front, the rectum is free in its upper portion, but is adherent below; its relations vary in the two sexes, and are of the greatest importance in a surgical point of view.

In the male its upper or free portion (*o, fig.* 181.) corresponds to the posterior surface of the bladder (*h*), from which it is separated, excepting in cases of retention of urine, or of considerable dilatation of the rectum by convolutions of the small intestines. Its lower or adherent portion is in immediate relation, in the middle line, with the inferior fundus (*bas-fond*) of the bladder,

at the triangular space intercepted between the vesiculæ seminales (*s*); on each side, it is separated from the bladder by these vesicles. The extent to which it is in contact with this part of the bladder varies in different subjects, and according as the bladder and rectum are full or empty.

We shall see in another place that the peritoneum (*u u*) forms a cul-de-sac of variable depth between them. In some subjects the cul-de-sac extends as far as the prostate, so that the whole of the inferior fundus of the bladder is covered by it.

In front of the inferior fundus of the bladder the rectum is intimately united to the prostate. (*i*) In some cases the prostate projects beyond the rectum, on one or both sides; in other cases the rectum projects beyond the prostate, on one or other, or both sides, and receives the gland, as it were, in a groove.

The rectum has also relations with the membranous portion of the urethra (*c*), but on account of its inflection backwards, it is separated from it by a triangular space, the base of which is directed downwards and forwards, and the apex upwards and backwards.

The practical inferences to be drawn from these relations are these,—that the bladder projects into the rectum in cases of retention of urine; that the bladder can be explored from the rectum, and may be punctured and cut for the extraction of stone; that the finger passed into the rectum can assist in the introduction of the catheter, and in examination of the prostate; that the rectum must be emptied before performing the lateral operation for stone; and lastly, that the membranous portion of the urethra may be opened without injuring this bowel.

In the female the free portion of the rectum corresponds with the broad ligament, the left ovary and Fallopian tube, the uterus, and the vagina. The peritoneum forms a cul-de-sac between the vagina and the rectum, analogous to that already described between the bladder and the rectum in the male, and subject to the same varieties. When the uterus and the rectum are empty, a certain number of convolutions of the small intestine are always interposed between the rectum and the vagina; and therefore, in lacerations of the posterior wall of the vagina, the small intestines escape through the wound.

The uterus and vagina are not unfrequently found deviating to the left side, while the rectum deviates to the right, and then the free portion of the latter corresponds to the right broad ligament and ovary. Lastly, in retroversion of the uterus, which is so common, the fundus of that organ rests upon the rectum.

The inferior or adherent portion of the rectum is intimately united to the vagina: hence vaginal cancer frequently extends into the rectum: below, on account of its inflection backwards, it is separated from the vagina in the same way as from the urethra in the male, by a triangular space, the base of which is directed downwards, and forms the perineum of the female.

On the sides the free portion of the rectum corresponds to the convolutions of the intestines; the adherent portion is surrounded by adipose cellular tissue, which is nowhere more clearly intended to fill up intermediate spaces; the absorption or destruction of this tissue is an important circumstance in diseases of the anus.

The *internal surface of the rectum* is remarkable for some longitudinal folds, which are obliterated by distension, and somewhat resemble the longitudinal folds of the œsophagus. These folds, which have been inappropriately termed the *columnæ* of the rectum, are intersected by other semi-circular folds, also effaced by distension. This internal surface presents, moreover a dilatation corresponding to the enlargement seen from without, immediately above the anus.

Structure of the large intestine. The same number of coats exist in the large as in the small intestine, but they present certain peculiarities in arrangement of which some are common to the whole bowel, while others exist only in particular parts.

The peritoneal coat. The peritoneum does not, in general, form so complete a covering for the large as for the small intestine. Moreover, it forms a great number of duplicatures on the surface of the bowel, which usually contain fat, and are called the fatty appendices (*appendices epiploicæ*). They are not constant, either in number, size, or length, but are sometimes arranged in regular series. Some of them are so long that they may form the contents of a hernial sac, or may even occasion strangulation, by forming a ring around the intestines; they are seldom entirely absent. They become lessened when the gut is distended, and are elongated by its contraction. They are sometimes loaded with an immense quantity of fat, of which they may be considered reservoirs. They are found along the whole of the large intestine, including the free portion of the rectum.

The peritoneum often envelopes the whole of the cæcum; at other times it does not cover it behind. Most commonly it forms a fold, or mesentery, for the vermiform appendix. It only passes in front of the ascending and descending colon, which are always uncovered behind. It invests the whole of the transverse arch, excepting a triangular space behind corresponding to the transverse mesocolon, and in another triangular space in front corresponding to the great omentum. It completely surrounds the sigmoid flexure, excepting in a small space behind, corresponding to the iliac mesocolon. Lastly, at the upper part of the rectum, it is arranged in a similar manner, and then merely passes in front of that bowel, the lowest portion of which is entirely devoid of a peritoneal covering, and is surrounded by a large quantity of adipose tissue.

From the arrangement of the peritoneum upon the large intestine it follows, that the latter is more favourably circumstanced than the small intestine for assuming a large size; and also that it may be penetrated in many places without injuring the peritoneum.

The muscular coat. As in the small intestine, this coat consists of a circular and a longitudinal set of fibres.

The *circular fibres* form the deep layer, and are arranged as in the small intestine; the *longitudinal fibres*, which constitute the superficial layer, are not disposed equally around the bowel, but are collected into three bands, which we have already noticed. These bands have the pearly appearance of ligaments when seen through the peritoneal covering *; they are continuous with the longitudinal fibres of the appendix vermiformis. The anterior is the largest; it becomes inferior along the arch of the colon, and again anterior upon the descending colon and sigmoid flexure, spreading out upon the latter. Of the posterior bands which are narrower, one is external and the other internal; they become superior on the arch of the colon, and again posterior upon the descending colon and sigmoid flexure, upon the latter of which they are often blended into one. I have already said that these bands, being not more than one third, or at most one half the length of the large intestine, occasion its puckering, and arrangement into sacculi and intervening depressions.

The muscular coat is remarkably modified in the *rectum.* In the sigmoid flexure the longitudinal fibres become scattered, and at its termination surround the whole intestine; but this arrangement exists more particularly in the rectum, where they present the appearance of thick fasciculi forming an uninterrupted covering (*r*, *fig.* 161.). The deep or circular layer of the rectum, is much thicker than that of any other part of the alimentary canal, excepting the œsophagus; it may be separated into distinct rings, the lowest of which is so distinct that it has been described as a particular muscle, under the name of the *sphincter internus.* It is arranged in precisely the same way as the corresponding coat of the œsophagus, but is not so thick: this difference depends upon the uses of the two canals, the œsophagus being intended to convey the food rapidly downwards, while the rectum is assisted by the abdominal muscles.

* [They are involuntary muscular fibres; in the lower part of the rectum some transversely striated fibres are found.]

When the rectum is empty it contracts upon itself like the œsophagus, and its walls are in contact.

The *fibrous coat* of the large intestine offers no peculiar characters.

The *mucous coat* of the large intestine has no valves: the semilunar crests, or ridges which separate the cells of the colon, are formed by all the coats. The irregular folds or wrinkles observed on this membrane are completely effaced by distension. The mucous membrane is not unfrequently protruded through the muscular fibres, so as to form small sacs having narrow necks, and containing masses of indurated fæces. At first sight such sacs resemble a varix. They are very common in the aged, and are probably the result of habitual constipation.

When examined with the microscope and under water, in the same manner as the mucous membrane of the small intestine, the inner surface of the large intestine is seen to have no villi, but we find exactly the same appearance as in the mucous membrane of the stomach, viz. an alveolar or honeycomb arrangement.* The openings or pores of this mucous membrane are innumerable; and supposing that they assist both in exhalation and absorption, it may be conceived with what rapidity these processes must be carried on in the large intestine. It is also studded with a number of follicles (tanquam stellæ firmamenti, *Peyer*), which are depressed and perforated in the centre *, and in a great number of subjects, especially in the old, have a black colour. These follicles are never collected into patches, as in the small intestine, but are always solitary. They are often inflamed, though the rest of the membrane is healthy.

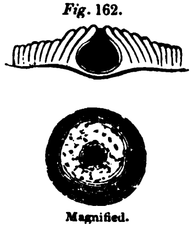
It is easy then to distinguish the large from the small intestine, simply from the characters of its mucous membrane. The limit between the two is at the free margin of the ileo-cæcal valve; all preceding this has the characters of the mucous lining of the small, all that comes after, of that of the large intestine.

We find dense patches of follicles in the vermiform appendix, the whole of which is sometimes lined with them.

The mucous membrane is more loosely united to the fibrous coat in the rectum than in any other part of the large intestine. This looseness is most marked at its lower part, and hence a protrusion of this membrane only may occur, as in the œsophagus; and this must be carefully distinguished from prolapsus of the entire rectum. I should also remark that the capillary veins are much developed at the lower part of the rectum, and, when much larger than usual, constitute what are called hæmorrhoidal tumours.

Vessels and nerves. The *arteries* of the cæcum, the vermiform appendix, the ascending colon, and the right half of the arch, are supplied by the superior mesenteric; the rest of the colon and the rectum receive blood from the inferior mesenteric. The rectum also receives a branch from the internal iliac, called the middle hæmorrhoidal, and a branch from the internal pudic, called the inferior hæmorrhoidal. Some small ramifications are also furnished to the great intestine by the gastro-epiploic, splenic, capsular, and spermatic arteries. The rectum exceeds all other parts of the large intestine in the

Fig. 162.



Magnified.

* [In the stomach this character is due to the presence of the alveoli, in the bottom of which the perpendicular tubuli open. In the large intestine, however, there are no pits; but the alveolar appearance is produced by the openings of numerous tubes, analogous in form and direction to the tubuli of the stomach, and to the crypts of Lieberkuhn in the small intestine.

The follicles of the large intestine differ from the solitary glands of the jejunum and ileum, in being always open. Each follicle is much dilated below, but has a narrow orifice. In *fig.* 162. the upper drawing represents a vertical section of a follicle (magnified), surrounded by the perpendicular tubes; the lower is a magnified superficial view, showing the depression and opening in the centre, and the orifices of the surrounding tubes.

The epithelium of this mucous membrane is cylindrical or columnar.]

number and size of its arteries, and therefore operations upon the lower part of that bowel are often followed by serious hæmorrhage.

The *veins*, which bear the same name and follow the same course as the arteries, concur in the formation of the great and small mesenteric or mesaraic veins, which terminate in the vena portæ.

The *lymphatic vessels* are very numerous, and terminate in the glands situated along the attached border of the intestine; the large intestine is also possessed of lacteals, but they are less evident than in the small intestine.

The *nerves* are derived from the solar plexus, and form plexuses along the arteries; they all belong to the ganglionic system. The rectum alone receives additional nerves from the cerebro-spinal system, viz. from the hypogastric and sacral plexuses. The presence of these two sets of nerves has reference to the functions of the bowel, which are partly involuntary, and partly subject to the influence of the will.

The anus. The word *anus*, borrowed from the Latin, signifies the lower orifice of the alimentary canal (the *anal orifice*); it is a narrow but dilatable opening, through which the fæces are expelled.

It is situated in the median line, about an inch in front of the point of the coccyx, at the back part of the perineum, between the tuberosities of the ischium, and at the bottom of the fissure between the buttocks. The skin around the borders of this orifice, which is constantly closed, contains a great number of sebaceous follicles, and is covered with hair in the male; it passes deeply into the orifice to become continuous with the mucous membrane, and presents a great number of radiated folds, which are effaced during dilatation. The point at which it becomes continuous with the mucous membrane is deserving of notice; it is within the rectum, at the distance of some lines from the anus properly so called, and is marked by a waved line, which forms a series of arches or festoons having their concavities directed upwards. Sometimes there are small pouches in the situation of these arches, opening upwards. From the angles at which the arches unite, some mucous folds proceed, and small foreign bodies detached from the fæces are often retained in the culs-de-sac, and become the causes of fistulæ.

Structure of the anus. The anus, intended as it is to prevent the revolting inconvenience of a constant and involuntary escape of the fæces, consists essentially of a *sphincter* muscle, which is antagonised not only by the proper dilator, viz. the *levator ani*, with which I connect the *ischio-coccygeus*, but also by the diaphragm and the abdominal muscles. The absence of a sphincter is the great evil of every artificial anus. A fourth muscle, the *transversalis perinei*, must also be included among the muscles of the anus.

The *skin* and the *mucous membrane* which cover these muscles are remarkable for the great developement of the erectile tissue, which forms the basis of all tegumentary membranes. The terminal branches of the hæmorrhoidal arteries are extended upon this portion of the skin and mucous membrane. From this erectile and therefore vascular tissue arise a great number of winding, twisted, and plexiform veins, which form the lowest roots of the vena portæ. A considerable number of cerebro-spinal and ganglionic *nerves*, derived from the sacral plexus and the hypogastric nervous centre, are distributed around this orifice. Lastly, there are mucous crypts, or rather glands, a vestige of the highly developed glandular organ found in some animals.

Muscles of the anus. We now proceed to the description of the muscles of the anus, which are six in number, viz. two single muscles, the *sphincter* and the *transversalis perinei*; and two pairs, the *levatores ani* and the *ischio-coccygei*, which in fact form but one muscle. The *sphincter internus* of authors is nothing more than the last ring of the circular fibres of the rectum.

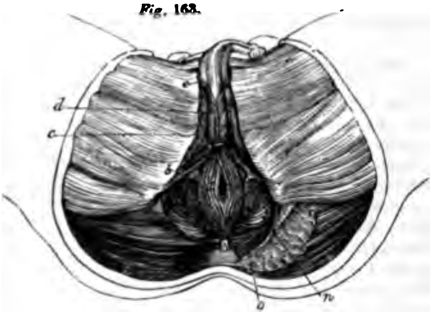
The Sphincter Ani.

Dissection. Remove carefully the corrugated skin which covers the anal region; prolong the dissection backwards as far as the coccyx, and forwards

to the scrotum in the male, and the vulva in the female. It is not sufficient to expose the lower ring of the sphincter; the adipose tissue which surrounds the lower part of the rectum should be removed on each side. It is well to stuff the lower part of the rectum preparatory to this dissection, as well as that of the muscles of the perineum.

The *sphincter ani* (*a*, *fig.* 163.) is an orbicular muscle situated around the lower end of the rectum. It is not a simple ring, but a muscular zone of nearly an inch in width. Its form is an ellipse, much elongated from before backwards, and terminating in a point in front and behind. The fibres which constitute the lowermost ring of the muscle *arise* from the subcutaneous cellular tissue in front of the coccyx, in the same manner as other cutaneous muscles; those which form the upper rings arise from a sort of fibrous tissue given off from the point of the coccyx. From these points the fleshy fibres proceed forwards, and form a semi-ellipse on each side, composed of parallel and superimposed muscular rings, which terminate in front of the anus in the following manner,—the lower rings in the subcutaneous cellular tissue, the upper rings in the sort of fibrous raphé, which gives origin to the bulbo-cavernosus.

Fig. 163.



Relations. The *internal surface* of the sphincter embraces the lower part of the rectum, the lowest circular fibres of which are seen within the sphincter, and are distinguished from it by their paleness. They constitute the internal sphincter. Its *external surface* is in relation with the adipose tissue of the pelvis. Its *upper border* is continuous with the antero-posterior fibres of the levator ani; so that it is very difficult to establish the limit between them.

Its *inferior border* projects a little below the lowest annular fibres of the rectum, and only adheres to the skin by loose cellular tissue, which is continuous with the dartos.

Action. It is a constrictor of the anus. The contraction of the body of the muscle closes the lower part of the rectum; the constriction produced by the inferior ring occurs below that bowel.

The Transversus Perinei.

Dissection. Remove with care the subcutaneous cellular tissue in front and upon the sides of the anus.

The *transversus perinei* (*b*) is situated almost transversely in front of the anus. It *arises* from the internal lip of the tuberosity of the ischium, immediately above the ischio-cavernosus (*erector penis*), by a broad and thin tendon, which is soon succeeded by fleshy fibres. These pass inwards and a little forwards, on to the anterior surface of the rectum, where they are usually described as becoming blended with those of the opposite side in a fibrous raphé, common both to the transversi, the sphincter, and the bulbo-cavernosi (*acceleratores urinæ*). This does not appear to me to be the exact termination. I have seen this muscle evidently continuous with that of the opposite side, after having traversed the anterior extremity of the sphincter. According to this, the two transversi would constitute a single muscle, forming a half ring, the concavity of which being directed backwards would embrace the anterior part of the rectum, an arrangement well calculated to assist in expulsion of the fæces.

Relations. This muscle is placed at the boundary between the anal and perineal regions. It forms the posterior side of a triangle, of which the outer side is formed by the ischio-cavernosus (*c*), and the inner by the bulbo-cavernosus. (*d*) It is subcutaneous excepting in the median line, and is in relation above with the levator ani.

Action. It tends to compress and force the anterior against the posterior surface of the rectum, which we shall see is pushed forwards by the levator ani. It therefore assists powerfully in defæcation.

The Ischio-coccygeus and Levator Ani.

Dissection. These muscles must be studied both from the perineum and from the interior of the pelvis. In the perineum: remove the adipose tissue, which occupies the interval between the rectum and the obturator internus; in order to expose the whole of the ischio-coccygeus, cut the lower edge of the glutæus maximus, and carefully divide the great and small sacro-sciatic ligaments. In the pelvis: remove the peritoneum lining the sides of that cavity; remove the superior pelvic fascia, which covers these muscles, and trace them very carefully backwards and upon the sides of the rectum, the bladder, and the prostate gland.

The *ischio-coccygeus* and the *levator ani* constitute the floor of the pelvis. They form an uninterrupted muscular plane, from the lower border of the pyriformis muscle to the arch of the pubes. The ischio-coccygeus includes that portion which is inserted into the sides of the coccyx, the remainder is the levator ani.

The Ischio-coccygeus, or Coccygeus.

This is a flat, triangular, or rather a radiated muscl (*o*), situated at the lower part of the pelvis, in front of the sacro-sciatic ligaments. It arises from the sides and summit of the spine of the ischium, from the anterior surface of the lesser sacro-sciatic ligament, and often from the posterior part of the pelvic fascia; it passes in a radiated manner to the border of the coccyx and the lower part of the border of the sacrum. All these attachments are effected by aponeurotic fibres, to which the fleshy fibres succeed. In this respect its structure has considerable analogy with that of the intercostal muscles, the tendinous portion exceeding the muscular.

Relations. Its *upper* surface (*o*, *fig.* 111.) is slightly concave, and corresponds to the rectum; its *lower* surface (*fig.* 163.) is slightly convex, and is in relation with the sacro-sciatic ligaments and the glutæus maximus; its posterior margin is applied to the lower border of the pyriformis; its anterior margin is continuous, without any line of demarcation, with the posterior margin of the levator ani (*n*), from which muscle it can be distinguished merely by its tendinous structure.

Action. It assists in forming the floor of the pelvis. It tends to draw the coccyx to its own side: when the muscles of both sides act together, the coccyx is fixed, and cannot be thrown backwards. It acts, therefore, in defæcation. The name *levator coccygis*, which was given to it by Morgagni, is altogether inapplicable.

The Levator Ani.

This muscle (*n*), so called from one of its chief uses, is situated in the cavity of the pelvis, and with its fellow forms a sort of muscular floor, which in many respects resembles that formed by the diaphragm. It is thin, curved, and quadrilateral, narrow in front and broad behind.

It arises, by its *fixed* or *upper attachments*, *in front*, from the pubis at the side of and sometimes even from the symphysis; *behind*, from the anterior border of the spine of the ischium, and in the interval between these extreme points from the upper part of the obturator foramen, and from the brim of the pelvis.

Its *moveable attachments* are to the side of the prostate, the bladder and the rectum, to the point of the coccyx, and to the fibrous raphé extending from that point to the sphincter. The fibres arising from the symphysis pubis are concealed by the pubio-prostatic ligament *: they are few in number, short, and directed inwards, backwards, and downwards, to form a bundle (the *prostatic*), which was described by Santorini as the *levator prostatæ*, and by Winslow as *le prostatique superieur*. The fibres arising from the spine of the ischium are blended at their origin with those of the coccygeus, and pass transversely inwards to the point of the coccyx. The origins from the upper part of the obturator foramen and from the brim of the pelvis take place by means of the pelvic aponeurosis, which divides and receives the muscle between its two layers (*i. e.* the superior pelvic and the obturator fasciæ). These fibres, the hindermost of which are the longest, all pass inwards, describe a curve having its concavity directed upwards, and are divided into the *vesical*, *anal*, and *præ-coccygeal*. The *vesical* fibres pass upon the sides of the inferior fundus (*bas-fond*) of the bladder. I have never seen them terminate on the vesiculæ seminales. The *anal fibres* having reached the sides of the rectum, above the sphincter, pass backwards, and meet behind the bowel. They constitute a half ring on each side, prolonging the sphincter upwards without any distinct line of demarcation. The *præ-coccygeal fibres* are directed backwards, and form a thick fleshy layer, occupying the interval between the coccyx and the sphincter, and completing the lower wall or floor of the pelvis. In the female there are also vaginal fibres.

Relations. Its upper or internal surface is covered by the superior pelvic fascia, which separates it from the peritoneum and the organs contained in the pelvis. The obturator fascia intervenes between its lower or external surface and the internal obturator muscle, from which it is separated below by a large triangular space, narrow above and broad below, and filled with adipose tissue. Its posterior part is in relation with the glutæus.

Action. It serves as a muscular floor for the pelvis. It raises the prostate, the inferior fundus of the bladder and the anus, and counteracts the effect of the diaphragm and abdominal muscles during violent exertions. It assists powerfully in the expulsion of the urine, the seminal fluid, and the fæces.

As the largest portion of the muscle occupies the sides and the back of the rectum, its especial use is to expel the contents of that bowel: this is effected by the præ-coccygeal fibres of both muscles elevating the rectum, and by their anal fibres drawing it forwards and upwards, and compressing it on the sides.

Functions of the large intestine. In the large intestine, the alimentary substances acquire the odour and all the other characters of the fæces; any remaining nutritious matter or chyle, which they may contain, is absorbed, and they become hardened and moulded in the cells of the colon. Absorption is sufficiently active in the large intestine, to enable life to be supported for a considerable period by means of nutritive enemata, in persons who cannot receive food into the stomach. The large intestine acts also as a reservoir; its long course, its curvatures, and its easily yielding character, enable it to contain a great quantity of matter, and prevent the inconvenience of constant defæcation.

The appendix vermiformis has no use in man; it is merely the trace of a largely developed intestine in herbivorous animals.

The rectum is the final reservoir, and one of the agents in the expulsion of the fæces, the presence of which gives rise to a sensation that informs us of the necessity for evacuating them. The sphincter, in general, opposes this evacuation, until it is determined upon by the will. The expulsion is effected by the action of the rectum, assisted by the diaphragm and the abdominal muscles.

* [*I. e.* by the anterior folds of the recto-vesical fascia, from which the fibres in question partly arise, and by which they are separated from the levator ani: the posterior layer of the triangular ligament is in relation with them in front.]

Developement of the Intestinal Canal.

The developement of the intestinal canal offers two subjects for consideration, viz. the relations existing between it and that portion of the fœtal membranes, called the *vesicula umbilicalis;* and the developement of the canal itself, independently of that vesicle.

In reference to the first point, the anatomy of the human fœtus is still involved in much obscurity, authorities being divided in opinion on the subject. Without entering here into a discussion which belongs to a higher department of anatomy, I would observe that the principal arguments adduced by those who admit the communication between the intestinal canal and the vesicula umbilicalis, are drawn from analogy, and especially from what occurs in oviparous animals, whose vitelline membrane is regarded as analogous to the umbilical vesicle, and in which the most evident communication exists at all stages of fœtal existence.

I would observe, also, that these same anatomists are not agreed respecting the point at which this communication occurs. According to Oken, it is at the junction of the small with the large intestine *: according to Meckel, it is at the lower part of the small intestine, and the diverticula so frequently observed in this place are vestiges of the canal of communication. The last named anatomist, after having discussed all the arguments on either side of the question, concludes thus:—"I think, then, that we must at present admit a continuity of substance between the umbilical vesicle and the intestinal canal, without pretending to decide whether the cavities of these two organs open into each other." (*Manual d'Anatomie*, tom. iii. p. 416. trad. par MM. Jourdan et Breschet.) But the communication of the cavities is evidently the entire question.

The arguments of those who deny the existence of a communication in the human fœtus and mammalia are founded upon direct observation. I must say with Emmert, Cuvier, and others, that I have never detected this communication; and though I am far from denying it altogether, yet I consider that facts are still wanting to prove its existence.†

The developement of the intestinal canal itself presents, besides some questions yet undetermined, certain positive facts, concerning which there can be no dispute. One of the undetermined questions relates to the mode in which the intestine is formed. Is the digestive tube originally an oblong vesicle, which becomes elongated, at the same time, at both its cephalic and its coccygeal extremities, both being at first imperforate, but afterwards opening so as to form the mouth and anus? Does it at first resemble a groove open in front, as Wolf has shown to be the case in birds; or is it developed from two lateral halves, subsequently united together according to the opinion of M. Serres? Is the intestinal canal formed from one, or from several centres of developement? Is it developed from several pieces, which afterwards meet each other, so to speak? and are any grounds for this opinion afforded by the absence of different portions of the canal in acephalous monsters, or the occasional existence of septa in different parts of its extent? I think not.

Upon the whole, these microscopical investigations into the first traces of the developement of organs, are still involved in great obscurity; and I must say that, whenever I have been able to discern the intestinal canal, it has appeared to me to form a complete cylinder.‡ Another question, which yet remains undetermined, relates to the situation of the intestine in the early periods of intra-uterine existence. It is at first situated, as some authors

* The vermiform appendix and the cæcum are the remains of this communication, according to Oken.

† [The communication has been distinctly seen and described by Dr. Allen Thomson. (*Edin. Med. and Surg Journ.* cxl. p. 132.)]

‡ [In the ovum, No. II., described by Dr. A. Thomson (*loc. cit.*), the future alimentary canal has the form of a groove.]

believe, in front of the vertebral column; or rather, as others imagine, in that portion of the cord which is next the umbilicus.

Embryologists agree in stating that, in the earliest periods of its developement, the intestinal canal is not contained in the abdominal cavity, but only its two extremities; all the intermediate part, *i. e.* almost the whole of the canal, is situated within the umbilical cord, which at that time is very considerably enlarged. The whole intestinal canal is not included in the cavity of the abdomen until towards the middle of the third month.

This fact is quoted in explanation of congenital umbilical hernia, which would be considered merely an arrest of developement. I must here remark, that this situation of the intestines, in a cavity formed within the umbilical cord, does not seem to me to have been clearly established; that there are a great number of cases where no such arrangement exists; that in other cases there is only a loop of the intestine in the substance of the cord; and lastly that the cases in which such an arrangement has been observed, if not examples of actual disease, may at least be regarded as instances in which the developement of the anterior wall of the abdomen had been retarded.*

Dimensions of the intestinal canal. The earlier the period of developement, the shorter and narrower is the intestinal canal. Its length at first appears to correspond to that of the vertebral column, a relation which is natural and permanent in a great number of the lower animals. The canal soon becomes flexuous, and its windings become more numerous in proportion as it increases in length. From the third to the fourth month, its curves are analogous to those which it subsequently describes: at the sixth month, the due proportion between the different parts of the canal is established. At the earlier periods, the small intestine has a much greater caliber in proportion to the large intestine, than it afterwards presents; and, on the other hand, the large intestine is relatively longer than at subsequent periods.

The division into the large and the small intestines does not exist at first. There is no ileo-cæcal valve, no cæcum, and no appendix vermiformis; but these three means of distinction appear simultaneously from the second to the third month.† The cæcum and the vermiform appendix are not distinct from each other, but present the appearance of a sort of funnel. The appendix, though at first small, is gradually developed, and becomes proportionally greater than it is afterwards; its caliber is nearly one half that of the small intestine. If it be not quite correct to say with Haller, that the cæcum does not exist in the fœtus, yet it must be admitted that, at this period of existence, it is nothing more than the expanded base of the vermiform appendix; and the developement which it acquires after birth may, to a certain degree, be regarded as the mechanical effect of the weight of the fæcal matters in dilating its cells. The anterior cells of the cæcum, on account of its vertical position, undergo a relatively greater amount of dilatation; and from this the vermiform appendix, which corresponded at first to the centre of the lower end of the cæcum, is turned backwards, inwards, and to the left side towards the ileum. The cæcum and the appendix do not occupy the right iliac fossa until the fourth or fifth month; before that time they are situated in the neighbourhood of the umbilicus. For the first four or five months of intra-uterine life, the large intestine is not sacculated; so that its external surface is exactly similar to that of the small intestine, the only means of distinguishing one from the other being the situation of the vermiform appendix. About the fifth month, according to Morgagni, the three longitudinal depressions, and the transverse folds or depressions and intermediate protuberances, make their

* [The presence of a portion of the intestinal canal within the umbilical cord, at some period of developement, is constant not only in man but in several quadrupeds, and cannot be merely accidental.]

† Haller, who in this and many other passages seems to have foreseen the law of unity of organisation, says, "Eadem primordialis hominis fere fabrica est quæ quadrupedum." (Lib. xxiv. p. 116.)

appearance simultaneously. These characters are first observed in the transverse arch of the colon.

The valvulæ conniventes of the small intestine do not appear until about the seventh month, and they are very slightly developed at birth. It is not uninteresting to remark, that the condition of the fœtus, in this respect, resembles that of animals, which never have valvulæ conniventes. The villi, however, can be observed as early as the third month. Meckel considers that they are developed from folds of the mucous membrane, the surfaces of which become notched. At the same period, according to that author, villi are very apparent in the large intestine; but, after the seventh month, they diminish in number and size, while those of the small intestine remain, even if they do not increase.

At first it is impossible to distinguish the several coats of the intestine: the serous and the mucous membrane can alone be recognised. The intestine is perfectly transparent.

The great omentum first appears during the third month, along the convex edge of the stomach, like a small and very thin border. Fat is never found within it before birth; nor are the appendices epiploicæ developed until after that event.

At birth, the intestinal canal presents the same characters as it afterwards possesses. The small intestine is already provided with rudimentary valvulæ conniventes, with well marked villi, and with very evident solitary and agminated glands. The large intestine, which is much developed, is distended with meconium; the cæcum is shorter than it afterwards becomes, the vermiform appendix is larger, and the ileo-cæcal valve has the same appearance as in the adult. The mucous membrane of the large intestine is already characterised by its solitary follicles and alveolar appearance.

In the large intestine of the fœtus we find, instead of fæcal matter, a thick, viscid, inodorous, and dark green substance, which fills the bowel more or less completely. This is the *meconium*, so called from the Greek word μήκων a poppy, because it bears some resemblance in colour and consistence to the juice of that plant. Its quantity increases towards the period of birth. The time at which it first appears has not been ascertained: I have found it in fœtuses of four or four and a half months, but then it only occupied the rectum. From the seventh to the ninth month it is accumulated in the sigmoid flexure, and diminishes in quantity towards the ileo-cæcal valve. The vermiform appendix is not unfrequently found distended with this matter. The small intestine also contains a mucous substance; but it is less abundant and less viscid, sometimes colourless, and sometimes yellowish or greenish.

The changes which take place in the intestinal canal after birth, affecting its caliber, its situation, and its length, appear to me to depend upon its being more or less distended with gas and fæcal matters, and on its being displaced in consequence of adhesions, increase of size, or displacement of other organs I have proved that in females who have had children, the intestines present more varieties in situation than in males. We may add, that these differences in position are much more frequently observed in the large than in the small intestine.

APPENDAGES OF THE ALIMENTARY CANAL.

The liver and its excretory apparatus. — The Pancreas. — The Spleen.

THE appendages of the sub-diaphragmatic portion of the alimentary canal are the *liver* and *pancreas*, two glandular organs which pour their secretions into the duodenum, and the *spleen*, which may be regarded as an appendage of the liver.

The Liver.

The *liver* (*l l' figs.* 155. 161.) is a glandular organ intended for the secretion of bile. Moreover, it is to this organ that the blood of the abdominal venous system is carried in the adult, and that of two systems of veins in the fœtus.

It is *situated* near the duodenum, *i. e.* the portion of the intestinal canal into which the bile is poured; it occupies the whole of the right hypochondrium, advances into the epigastrium, and even slightly into the left hypochondrium. It is protected by the seven or eight lower ribs on the right side, which defend it from external violence; and it is separated from the thoracic organs by the diaphragm. It is supported by folds of the peritoneum connecting it with the diaphragm, and regarded as suspensory ligaments; by the stomach and intestines, which form a sort of elastic cushion for it; and by the vena cava, which is intimately adherent to it. These means of support and attachment allow of slight movements to and fro, and even of certain changes of position, not amounting to displacement. Thus it is depressed during inspiration, and projects a little below the edges of the costal cartilages; it is raised during expiration; it sinks slightly downwards during the erect posture, and backwards, or in the direction in which its own weight would drag it, according to the way in which the body lies during the horizontal position; it is pushed upwards by tumours in the abdomen, and downwards by effusions in the chest. The disturbed sleep to which many individuals are subject when lying upon the left side, is attributed to the pressure of the liver upon the stomach; and to the dragging of the liver upon the diaphragm has been ascribed the sensation of hunger, as well as the relief of that feeling produced by tying something tight around the abdomen. These notions are, however, purely hypothetical; and generally, in solving such questions, the exact state of fulness of the abdomen, and of the mutual action and reaction of the abdominal parietes and viscera, has not been sufficiently taken into account. True displacements of the liver are very rare, and *hepatocele* (hernia of the liver) is the result of an imperfect developement of the walls of the abdomen.

Size. The liver is the largest and heaviest of all the organs of the body; and indeed, in the human subject, it exceeds in weight and in size all the other glands together. It is not true, as the ancients declared, that the liver is larger in man than in any other animal. But the opinion maintained by many naturalists, that there is, in the animal series, an inverse ratio between the size of the liver and the developement of the respiratory organs, so that this organ is much larger in reptiles and fishes, whose respiration is slight, than in birds and mammalia, which respire vigorously, is not altogether devoid of foundation.

The liver weighs from three to four pounds, thus forming one thirty-sixth of the whole weight of the body according to Bartholin, and one twenty-fifth according to others. Its longest diameter, the transverse, is from ten to twelve inches; its antero-posterior diameter is from six to seven inches; and its vertical diameter in the thickest part from four to five. These dimensions are extremely variable, but are always inversely proportional to each other. In a great many livers the transverse diameter is the shorter, and the vertical the longer.

Few organs present a greater variation in size and form in different individuals than the liver. I am certain that the relative proportion between different livers may be as much as one to three, in the absence of all disease. It is pretty generally believed, that a large liver occasions such modifications in the whole system, as will give rise to a particular temperament. But it may be doubted whether there is any proof, that the bilious and melancholic temperaments, are specially accompanied by a large liver, or that hypochondriasis in particular is the result of a predominance of that organ.* Anatomical evi-

* Hippocrates sometimes gave the name of *hypochondria* to the liver, and hence no doubt the term *hypochondriac*.

dence affords but little support to such ideas, which are rather the result of preconceived notions respecting the functions of the liver and the influence of the bile, than the fruit of positive observations.

It varies much in size according to the state of its circulation; when its vessels, and especially the ramifications of the vena portæ are empty, the tissue of the liver shrinks, and its surface becomes, as it were, wrinkled. When, on the other hand, the hepatic vessels are injected, the organ is in a state of turgescence. I have often been struck with the increase in the size of the liver, produced by an injection pushed forcibly and continuously into the vena portæ.

The size of the liver, as influenced by age and disease, deserves particular attention. I shall point out the influence of age under the head of developement. We shall then see that the liver is largest during intra-uterine life; and that it is proportionally larger at periods nearer to that of conception: hence it arises that the greatest relative size of the liver is coincident with the least amount of biliary secretion; and we may therefore conclude, that this organ has some other use besides that of secreting bile.

When diseased, the liver has been found to weigh from thirty to forty pounds, but the enormous size in these cases is almost invariably owing to the developement of accidental tissues. Some cases, however, have been recorded, of simple hypertrophy of the liver without any organic disease, in which the size acquired was prodigious. In opposition to this we must notice the state of atrophy * in which the liver is shrivelled, and not more than a third, fourth, or even a sixth of the natural size. In one subject in which the umbilical vein remained pervious, and the subcutaneous abdominal veins were dilated and varicose, the liver weighed only about half a pound.

The specific gravity of the liver is, to that of water, as fifteen to ten.

Figure. The liver is a single and asymmetrical organ, of such an irregular form as to defy description. We shall compare it, with Glisson, to a segment of an ovoid, cut obliquely lengthwise, thick at its right extremity, and progressively diminishing towards the left, which terminates in a tongue. Its shape is represented by the sort of mould formed by the right half of the diaphragm, and bounded below by an oblique plane directed upwards, and to the left side (*fig.* 161.).

No organ is more exactly moulded upon the surrounding parts, nor undergoes changes in form with greater impunity, either from external pressure, or from that exercised upon it by other viscera: it may even be said to be, as it were, ductile or malleable under the influence of a slowly-exerted pressure. The injurious effects of very tight lacing are chiefly experienced by the liver. A circular constriction and a fibrous thickening of this organ opposite the base of the thorax, sometimes afford evidence of this compression; its transverse and antero-posterior diameters become diminished, and its vertical diameter is increased; it projects more or less below the base of the thorax, descends as low down as the right iliac fossa, and may even touch the brim of the pelvis without any structural lesion. In these cases its upper surface becomes anterior, and its lower surface posterior.

There are but few female subjects without some deformity of the liver; and therefore the type of the organ must be sought for in the male. † No practical conclusions then can be derived from the shape of the liver; and I am almost inclined to agree with Vesalius in saying, that it has no determinate form, but accommodates itself to the surrounding parts. In a few rare exceptions we find the human liver divided into lobules by deep fissures, as it is in a great number of animals. The errors which have for a long time existed upon this subject, even since the time of Vesalius, arise from a blind re-

* We cannot admit the proposition of Sœmmering,—" Quo sanior homo, eo minus ejus hepar est."

† Sœmmering, without giving any reason, says, " *In sexu masculo magis, minus in femineo costis istis tectum latet.*" (*Corpor. Hum. Fabric.* t. vi. p. 163.)

spect for the assertions of older anatomists, who, having dissected few human subjects, were accustomed to confound in their descriptions the structure found in animals with that observed in man.

The liver presents for consideration a superior or convex surface, an inferior or plane surface, an anterior and a posterior border, a base, and a summit.

The *superior surface* (*pars gibba*) is convex and smooth, and in contact with the diaphragm, which is moulded exactly upon it: this convexity is not regular, but much greater on the right than on the left side, where the surface is almost flat (*fig.* 161.). This surface is divided into two unequal parts (*l l'*) by a falciform fold of peritoneum (1 to 2), called the *falciform* or *suspensory ligament of the liver*, which seems to be principally intended to protect the umbilical vein, and which is never put upon the stretch during the natural state of fulness of the abdomen. One or more fissures are not unfrequently found running from before backwards upon the upper surface of the liver; and I am sure that these fissures, in explanation of which Glisson and Fernel have advanced some very singular opinions, are due, at least in some cases, to the pressure of projecting folds of the diaphragm. The falciform ligament forms the line of separation between the *right* (*l'*) and the *left* (*t*) *lobes*, a purely nominal distinction, which results from the old habit of admitting several lobes in the liver, and is retained here only for the sake of conformity to custom. The portion of the liver situated to the left of the suspensory ligament is always smaller than that upon the right.

The convex surface of the liver is bounded behind by the reflection of the peritoneum upon it from the diaphragm. It is separated by the diaphragm from the heart, the ribs, and the base of the right lung. Its relations with the base of the right lung are very extensive; the base of the lung and the convexity of the liver are exactly fitted to each other: this may be shown by making a vertical section from before backwards, upon the right side of the trunk, when the liver will be seen to be received, as it were, into a deep excavation in the base of the lung. This relation explains why abscesses and cysts of the liver may burst into the lung, and why abscesses of the lung point towards the liver; why the liver may increase in size in the direction of the thorax, and push up the lung as far as the third or even the second rib; and why effusions into the pleura may force the liver downwards in the abdomen; and also why peritonitis, confined to the region of the liver, is sometimes mistaken for pleurisy at the base of the thorax. The relations of the liver with the seven or eight inferior ribs, account for the impressions which are often seen upon its surface; and also explain the facts, that violent blows upon the ribs may bruise this viscus; that pointed instruments thrust into the intercostal spaces on the right side may wound it; and that abscesses of the liver point and open between the ribs.

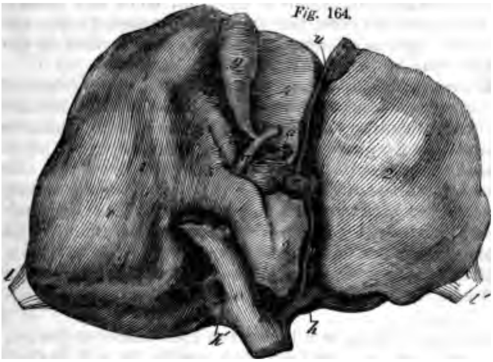
The relations of the convex surface of the liver with the abdominal parietes, which are so extensive in the new-born infant, and still more so in the fœtus, are generally confined in the adult to a variable extent of the epigastrium, and to a small space below the edges of the ribs on the right side (*fig.* 155.). In certain conformations of the liver (almost always acquired), and in such diseases as are attended with an increased size of the organ, these relations become much more extended; and even in the absence of any disease, the liver is not unfrequently found to extend into the neighbourhood of the umbilicus, or even into the right iliac region. In the erect posture the liver has a tendency to project below the ribs; and therefore the sitting posture, with the upper part of the body inclining forwards, and resting upon some object, is the most favourable one for exploring this organ.* It is by no means rare

* In an old woman, whose liver was deformed but healthy, and projected below the ribs, I was able to diagnosticate, by mediate percussion, the existence of a knuckle of intestine between the liver and the parietes of the abdomen. Very lately I found a large loop of the transverse arch of the colon between the right lobe and the abdominal parietes, and a loop of the small intestine between the left lobe and those parietes.

to meet with accidental adhesions between the liver and the diaphragm, consisting either of cellular filaments in the form of bands, or of cellular tissue of a greater or less density.

The *inferior* or *plane surface* (*pars sima*, *l l*, *fig.* 154. and *fig.* 164.). This is much more complicated than the upper surface, and upon it the hepatic vessels enter and make their exit from the liver. Certain eminences and depressions, or fissures of variable depth, are met with here, which have led to the division of the liver into several lobes; but that kind of division, which in animals appears to enable the organ to adapt itself to the form of the viscera of the abdomen, and has probably some relation with the conformation of the heart, cannot be said to exist in man.* This lower surface is directed downwards and backwards, and sometimes directly backwards: it presents for our consideration, in the first place, an *antero-posterior fissure*, or *fissure of the umbilical vein*, called also the *longitudinal* or *horizontal* fissure (*u h*, *fig.* 164.), which extends from the anterior to the posterior border of the liver, and is divided by the transverse fissure (*d p*), meeting it at a right angle, into two halves, one anterior, the other posterior. The anterior half lodges the umbilical vein in the fœtus †, or the fibrous cord (*u*), to which it is reduced in the adult: the posterior half lodges the ductus venosus in the fœtus, or the fibrous band (*v*), by which it is replaced after birth. The anterior half of the longitudinal fissure is much deeper than the posterior, and is often converted into a complete canal by a sort of bridge formed by a prolongation of the substance of the liver: when incomplete, this bridge is always situated near the transverse fissure: it often consists of a band of fibrous tissue. Even when quite complete, it invariably presents a notch near the anterior border of the liver.‡ The posterior half of the longitudinal fissure inclines more or less obliquely to the left of the lobulus Spigelii (3), gives attachment like the transverse fissure to the gastro-hepatic omentum, and communicates with the fissure for the vena cava superior (*c*), behind the lobulus Spigelii.

Fig. 164.



The existence of this fissure has been the chief cause of the division of the liver into the *right* or *great lobe* (1), and the *left lobe* (2), also termed the *middle-sized lobe* by those anatomists who admit as a third lobe the *small lobe*, the *lobule*, or the *lobulus Spigelii* (3). This division of the liver into two lobes is also marked on the upper surface, as we have already seen, by the suspensory ligament. Of these lobes the right is much larger than the left; the former occupies the right hypochondrium; the latter the epigastrium and left hypochondrium (*fig.* 161.). The proportion between the right and the left lobe cannot be precisely determined. The left lobe is sometimes reduced to a thin tongue, while at other times it is almost half the size of the right lobe.

* The ancients admitted four lobes in the liver, which they distinguished by the singular names of *mensa*, *porta*, *gladius*, and *unguis*.

† [The term umbilical fissure is often restricted to this part of the longitudinal fissure; the posterior half is then called the fossa of the ductus venosus.]

‡ [This bridge was purposely divided in the liver from which *fig.* 164. was drawn.]

Generally, the relative proportion between them is as six to one. This, however, is but of little consequence; for as the distinction between the two lobes is quite imaginary, the substance of the left may without any inconvenience be included in the right, and *vice versâ*. The *transverse fissure* or *fissure of the vena portæ* (*d p*) is the true *hilus* of the liver, for through it the hepatic vessels enter and pass out. It is a very broad transverse fissure, from fifteen to eighteen lines in length, occupying almost the middle of the lower surface of the liver, a little nearer to the posterior than to the anterior border, and to the left than to the right extremity. It is bounded on the left by the longitudinal fissure, with which it communicates; to the right of the gall bladder (*g*), it is prolonged obliquely forwards by a deep and narrow cleft. In the transverse fissure we find the vena portæ, or the sinus (*p*) of the vena portæ, the hepatic artery (*a*), the roots of the hepatic duct (*d*), a great number of lymphatic vessels and nerves, and a considerable quantity of cellular tissue. The gastro-hepatic omentum is given off from this fissure. The transverse fissure is situated between two eminences, called by the ancients the pillars of the gate (*portal eminences*). All the peculiarities of the inferior surface of the liver may be referred to these two fissures.

Thus, *to the left of the longitudinal fissure* we observe the inferior surface of the left lobe, slightly concave behind, where it is applied to the lobulus Spigelii, from which it is separated by the gastro-hepatic omentum; concave in front, so as to be adapted to the convexity of the stomach, upon which it is prolonged to a greater or less extent. This relation of the liver with the stomach is of the utmost importance. Thus, when the stomach is distended, it pushes the liver upwards and backwards in such a manner, that its lower surface is directed somewhat forwards. In cases of chronic ulceration of the stomach, the tissue of the liver is not unfrequently found supplying the place of the destroyed coats of the stomach, and this to a considerable extent. The lower surface of the left lobe is often in relation with the spleen, which it occasionally covers like a helmet.

To the right of the longitudinal fissure, and in front of the transverse fissure, we find, upon the lower surface of the right lobe, the *fossa for the gall bladder*, which is more or less deep, oblong, and directed from before backwards, upwards, and to the left side, like the gall bladder (*g*) itself, for the reception of which it is intended. This fossa is not always prolonged as far as the anterior border of the liver. Between the fossa of the gall bladder and the longitudinal fissure is a square surface, the *lobulus quadratus*, *anterior portal eminence* or *anterior lobule* (4). This surface sometimes terminates behind in a distinct rounded prominence, which justifies the name of eminence applied to it; at other times, on the contrary, this portion of the liver is flattened.

Behind the transverse fissure we find the *posterior portal eminence*, or *small lobe* (*posterior lobule* or *lobule*), also called the *lobulus Spigelii* (3), from the name of the anatomist to whom its discovery has been attributed, although it was described, and even figured before his time by Vesalius, Sylvius, and Eustachius. It varies much, both in size and shape, and is situated between the transverse fissure and the posterior border of the liver, and between the fissure of the ductus venosus (*v*) on the left, and the fissure of the vena cava inferior (*c*) on the right. It is situated to the right of the œsophageal orifice of the stomach, opposite its lesser curvature, by which it is embraced; its form is that of a flattened semilunar tongue, convex upon its lower and free surface, which corresponds to the upper border of the pancreas, and has a projection in the centre, surrounded by an arterial circle, formed by the coronary artery of the stomach with the splenic and hepatic arteries. This projection (above 3), is called by Haller, *major colliculus in magnæ papillæ similitudinem*; and by Winslow, *l'eminence triangulaire*. From its posterior extremity a prolongation is given off opposite the posterior border of the liver, which converts the fissure for the vena cava inferior into a canal that is some-

times complete.* A prolongation, or ridge (5) (*the right prolongation of the lobule*), passes from its anterior extremity to the right of the transverse fissure, and proceeding obliquely forwards, separates the renal (*r*) from the colic (*o*) depression. This prolongation was minutely described by the older anatomists, and has been termed by Haller the *colliculus caudatus.*† At its junction with the lobule, this prolongation is marked in front by a groove (the *groove of the vena portæ*), sufficiently deep to lodge the vena portæ (*p*) and the hepatic artery (*a*); and it is still more deeply excavated behind for the vena cava inferior (*c*) (*the groove of the vena cava inferior*). Sometimes the right margin of the first mentioned groove has a papilla, similar to that of the lobulus Spigelii; and in this case it might be said, that there are two lobes of Spigelius; opposite this groove, the vena portæ is separated from the vena cava only by a very thin lamina.

The lobulus Spigelii presents much variety in its size; but not such as to enable it to be felt through the abdominal parietes, unless the enlargement is the consequence of disease. Physicians who pretend to recognise by the touch obstruction, or adhesion of the lobulus Spigelii ‡, are certainly not anatomists.

To the right of the longitudinal fissure, the lower surface of the liver presents, behind, an excavation of variable depth and extent in different subjects; this is the renal impression (*r*): it corresponds to the kidney, upon which it is exactly moulded, and with which it is loosely united, and also, though more loosely, with the suprarenal capsule. Sometimes the impression for the capsule is distinct from that for the kidney. It may be conceived that this impression must vary according as the liver corresponds to the upper third, to the upper half, or to the whole of the right kidney. This impression is always directed backwards.

In front of the renal impression is a slight one, termed the colic depression (*o*), which corresponds with the angle formed by the ascending and transverse colon with part of the transverse colon itself, and sometimes also with the first portion of the duodenum.

Behind is the groove for the *vena cava inferior* (*c*), which advances slightly upon the lower surface of the liver, on the inner side of the renal and capsular impression.

The accidental fissures sometimes observed upon the lower surface of the liver, are traces of the divisions which exist in a great number of mammalia.

To recapitulate the numerous objects seen upon the lower surface of the liver, we find as follows: — the antero-posterior or longitudinal fissure intersected at right angles by the transverse fissure; on the left of the antero-posterior fissure is the lower surface of the left lobe, presenting the depression for the lobulus Spigelii, the gastric impression, and sometimes the splenic; on the right and in front of the transverse fissure, are the fossa of the gall bladder, and the anterior portal eminence, or lobulus quadratus; behind the transverse fissure is the posterior portal eminence or lobulus Spigelii, with its right prolongation or lobulus caudatus, and the groove for the vena portæ; and still more to the right are the renal and colic impressions, and the groove for the inferior vena cava.

The circumference of the liver. The *anterior* border of the liver presents a very thin, and, as it were, sharp edge, which is directed obliquely upwards and to the left side, corresponding to the base of the thorax on the right side, and projecting below it opposite the substernal notch (*fig.* 155.). Upon this edge there is invariably found a deep notch (below 2, *fig.* 161.) for the umbilical vein; and more to the right another notch, which is often larger

* [This prolongation did not exist in the liver represented in *fig.* 164.]

† [Now termed the lobulus caudatus.]

‡ Meckel and others consider that there is a right antero-posterior, or longitudinal fissure formed by the fossa for the gall bladder and the groove of the vena cava inferior; the latter groove being partly hollowed out of the lobulus Spigelii, and partly out of the contiguous portion of the right lobe, and then prolonged upon the lower surface of the liver.

than the preceding, and corresponds to the base (*g*) of the gall bladder. Sometimes there is merely a trace of this notch, and sometimes it is altogether wanting. In some subjects there is only one great notch common to the gall bladder and the umbilical vein, and the borders of it are sinuous, or cut into small notches. It is almost always possible, when the parietes of the abdomen are relaxed, to insinuate the fingers between the ribs and the liver.

The *posterior* border of the liver is very thick in all that part which corresponds to the right side, and becomes gradually thinner as it approaches the left extremity. This border, which is short, rounded, and curved, so as to fit the convexity of the vertebral column, adheres intimately to the diaphragm by rather dense cellular tissue. The peritoneum is reflected, both above and below this border, from the diaphragm to the liver, to form what is called the *coronary ligament*. The cellular interval between these two layers of peritoneum is of irregular form, and varies in size. This border is divided into two parts by a deep notch, which forms two thirds or three fourths of a canal for the reception of the inferior vena cava (*c*, *fig.* 164.). This notch is converted into a complete canal, sometimes by a sort of fibrous bridge, and sometimes by a prolongation from the posterior extremity of the lobulus Spigelii. In order to comprehend the arrangement of the liver opposite this notch for the vena cava, that vein should be slit open, and we then see at the bottom of a deep notch a large cavity, into which all the hepatic veins (*h h*) open. We observe, also, that the antero-posterior fissure is continuous with the fissure of the vena cava, behind the lobulus Spigelii. This lobule, viewed from behind, appears like a tongue detached from the rest of the liver, by circumscribing fissures and grooves.

On the right side the liver terminates in a thick smooth extremity, forming the base of the pyramid to which this organ has been compared. A triangular fold of peritoneum, called the *right triangular ligament* (*l*), is stretched from the middle of this thick extremity to the diaphragm.

On the left side the liver terminates in an angular or obtuse tongue, more or less elongated, and sometimes reaching as far as the spleen, to which I have seen it adherent. This prolongation, which is attached to the diaphragm by a triangular fold of peritoneum, called the *left triangular ligament* (3, *fig.* 161.; *l*, *fig.* 164.) is slightly notched behind for the lower end of the œsophagus, which is bordered by it upon the left side. In one subject I saw this tongue completely separated from the rest of the liver, with the exception of a vascular pedicle about four lines in length. This peculiarity was probably owing to traction exercised by the spleen, to which the prolongation from the liver was intimately adherent.

Colour. The liver is of a reddish brown colour, the depth of which varies in different individuals. Its surface, and also sections of it, resemble in appearance a granite composed of two kinds of grains, the one deep brown, the other yellowish ; and hence has arisen the distinction between the two substances of the liver. In no tissue in the body is there greater variety in colour, than in that of the liver. Independently of the different shades which it is impossible to describe, the liver is sometimes of a yellowish, or canary-yellow, or a chamois-yellow (hence the name *cirrhosis* given to a particular disease of the liver); or it may be of a more or less deep olive green hue ; or of a slate colour. These differences in colour, which have not perhaps been sufficiently investigated, are connected with more or less decided alterations of texture. The chamois-yellow colour almost always indicates the existence of fatty degeneration.

Fragility. The fragility of the liver is one of the most important particulars in its description. It is *compact* and *fragile*, and cannot therefore be forcibly compressed without suffering laceration ; hence the danger of contusions in the region of the liver, and the rules laid down by accoucheurs for avoiding all compression of the abdomen of the fœtus during the manipulations required in protracted labours. The fragility and the weight of the liver explain the occurrence of injuries of that organ by contre-coup, after falls from an

elevated height. In fatty degeneration of this organ, the liver retains the impression of the finger, and its fragility is in a great measure lost. Olive green and slate coloured livers are dense, their molecules are much more closely united, and they are lacerated with difficulty.

Texture. Before the admirable works of Glisson and Malpighi, anatomists were in the habit of saying with Erasistratus, that the liver, like all other organs of a complicated structure, was a *parenchyma*, a vague term intended to imply the effusion of a particular juice around a series of vessels. Malpighi showed, in opposition to the assertion of Warthon, that the liver is a conglomerate gland; he examined the glandular granules (the lobules of Kiernan), which Ruysch subsequently, by means of his beautiful injections, appeared to convert into vessels. Anatomists are still divided between the opinions of these two eminent observers, concerning the intimate structure of the liver, as well as of all other glands, some believing it to be granular, others that it is vascular. We have to consider the coverings and then the proper tissue of the liver.

The coverings of the liver. These are two in number, viz. a peritoneal coat and a proper fibrous membrane.

The *peritoneal coat* forms an almost complete covering for the liver; the posterior border, the transverse fissure, the groove for the vena cava, and the fossa for the gall bladder, are the only parts that are destitute of this coat. The peritoneum, from being reflected upon the liver from the diaphragm, constitutes the several folds called the falciform, coronary, and triangular ligaments, of which we have already spoken. By means of this membrane, which is always moist, the liver is enabled to glide upon the adjacent parts without friction. We frequently find cellular adhesions between the liver and surrounding structures, which do not positively impair its functions. The peritoneal coat adheres intimately to the proper membrane.

The *proper* or *fibrous membrane* is very well seen over such portions of the liver as are not covered by the peritoneum, and from these points it can be easily traced over the whole of the remainder of the organ. It constitutes the immediate investment of the liver; its outer surface is adherent to the peritoneal coat, and its inner surface is connected with the tissue of the liver by means of *fibrous prolongations* interposed between the granules (lobules), affording to each a distinct covering.

It passes into and lines the transverse fissure, and is prolonged around the corresponding divisions of the vena portæ, the hepatic artery, and the biliary ducts, so as to form cylindrical sheaths for those groups of vessels, and for all their further divisions and subdivisions. These sheaths constitute the *capsule of Glisson*, which we must therefore regard as a dependence of the proper fibrous coat. The internal surface of these sheaths is united to the vessels only by a very loose cellular tissue. Their external surface adheres intimately to the tissue of the liver by fibrous prolongations, which interlace in every direction, and form distinct coverings for the deep-seated granules, analogous to those which we have already stated are produced from the proper coat. The liver therefore is traversed in all directions by very delicate fibro-cellular prolongations, forming a vast network in which the granules are contained. This proper coat moreover is fibrous †, not muscular as Glisson believed.

It may be said with truth to constitute the skeleton or framework of the liver; for it affords a general covering for the organ, it is prolonged around the vena portæ, the hepatic artery and the biliary ducts, and it furnishes a fibrous or cellular covering for each of the granules composing the proper tissue of the liver. The fibrous cells thus formed become very distinct in certain cases of hepatic disease. In fact, this fibrous tissue not unfrequently becomes

* [It is composed of dense cellular or fibro-cellular tissue; for its use, see note, p. 521.]

so much hypertrophied, that some of the glandular granules are compressed and atrophied; and then larger or smaller portions of the liver appear to be converted into a reticulated fibrous tissue. The arrangement of the fibrous tissue is also very manifest in cases of softening of the granules, which may then be easily scraped out of their cells, and the surface of the section thus treated presents the appearance of the cells in a honeycomb.

The proper tissue of the liver. The first thing that strikes an observer in examining the structure of the liver, is the smoothness of its external surface, which does not present any of the lobulated appearance of most other glands. If we attentively examine this surface, either before or after the removal of its coverings, we find that it is most distinctly composed of granules (lobules, *Kiernan*): the same is also rendered evident by making sections of the organ, or by tearing it: the granular arrangement has, it is true, been supposed to be the result of laceration.

From the mottled appearance of the liver (like granite), already noticed, anatomists have admitted the existence of two substances, or rather two kinds of granules in this organ; viz. *reddish brown* and *yellow* granules. This distinction was first made by Ferrein (*Hist. Acad. des Sciences*, 1735); it is now generally recognised, and has even served as the basis of several more or less ingenious explanations. This anatomist called the brown substance *medullary*, and the yellow *cortical*, names evidently derived from a rude analogy between them and the medullary and cortical substances of the brain. Others have reversed the meaning of these two words; but that is of little consequence.

"These two substances," says Meckel, "are not arranged as in the brain, one external and the other internal; but alternately throughout the whole liver, the yellow substance forming the mass of the organ, and the brown substance occupying the intervals."

This distinction into two substances does not appear to me to be well founded. The error has arisen from assuming as constant, the existence of two colours, which however are far from being distinguishable in all subjects. The two colours, yellow and brown, when they do exist, do not belong to two distinct granules; but rather to the same granule, which is yellow in the centre, where the bile is found; and reddish brown at the circumference, where the blood is collected.*

The granules of the human liver are so small, that excepting when they become considerably enlarged, it is not well adapted for examination. The liver of the pig, in which the granules are naturally very large, appears to me the best suited for this purpose. I have been accustomed to divide the liver in different directions, to slit up and remove the veins which have been cut across, and afterwards to examine the granules in the semi-canals (*g g, fig.* 165.; *c c, fig.* 166.) which they then form. The granules (*l l l*) may thus be separated with the greatest facility; they are small ovoid, elliptical, or rather polyhedral bodies, having five or six surfaces, and shaped so as to be moulded upon the surface of the adjacent granules, without leaving any interval. It is evident, therefore, that there is only one order of granules; that these granules are not arranged in lobules, as stated by Malpighi†, but are merely in juxta-position; and that each has its proper capsule formed by prolongations of the fibrous coat. And as these granules can be isolated, and detached from the capsules in which they are merely lodged, without adhering to them, except at the points by which they receive and emit their vessels, it follows that they are independent of each other, and that the most complete alteration of one or more of them may take place, without the adjacent or intermediate

* See note, page 524.

† [This statement illustrates the confusion that has prevailed from the terms *lobule* and *acinus* having been employed by anatomical writers in different senses to those attached to them by Malpighi; the lobule of Malpighi is, in fact, equivalent to the granule of M. Cruveilhier, and was described by him as consisting of a collection of acini (see note, p. 524.).]

granules being in any way affected, or at least that such alteration would not be propagated by continuity of tissue.

The size of the granules varies much in different individuals, and is quite independent of the size of the liver itself. Physicians who have paid much attention to pathological anatomy, have often mentioned their increased developement, by the name of *hepar acinosum.* This disease is characterised by the simultaneous occurrence of atrophy of the entire organ, which is reduced to one-half or one-third its original size, and of hypertrophy of the granules themselves. In what is called *cirrhosis*, the greater number of the granules are atrophied.*

The investigation of the structure of the liver is then reduced to the determination of the arrangement of the granules with respect to each other, of the mode in which the vessels are arranged, and of the structure of each granule.

1. The *arrangement of the granules*, with regard to each other, is revealed by the following fact: — In the disease of the liver called *ramollisement* (*Dict. de Méd. et Chir. Pratiq.*, art. MALADIES DU FOIE), in which that organ is reduced to a sort of pulp, as soon as the investing membranes are torn, the tissue of the liver escapes like a brownish yellow pulp, which, as it is not fetid, cannot be supposed to be the result of gangrene. If this pulp be placed in water, myriads of small and very distinct yellow granules will be seen, resembling small raisin stones, and appended to the ramifications of the different kinds of vessels by vascular pedicles.

This fact, which I have several times observed, is confirmed by the observations of Harvey, who in his work upon the generation of animals says, that the tissue of the liver is formed along the umbilical vessels like a grape on its footstalk, a bud on the end of a twig, or an ear of corn springing from its stalk; and also by reference to comparative anatomy, for M. Blainville has informed me, that, in certain species of animals, the liver is formed by rows of glandular granules attached along the vessels.†

2. *The vessels of the liver.* The study of the vessels of the liver is one of the most important points in the history of that organ. Besides the arteries and veins corresponding to those of other parts of the body, the liver receives also a special system of veins, viz. *the system of the vena portæ*, which is distributed in its interior like an artery. It presents also, in the adult, the remains of a venous system peculiar to the fœtus, *the system of the umbilical vein*; and lastly, it contains canals intended for the conveyance of the bile, named the *biliary ducts*.

The special venous system of the liver, or *the system of the vena portæ*, will be described more particularly in another place. I shall only now observe, that the branches of origin of this system commence in all the abdominal organs concerned in the function of digestion; that the ventral vena portæ, resulting from the union of these branches, reaches the transverse fissure of the liver, and divides there into a right and left branch, which constitute the

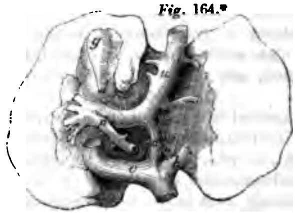
* The ingenious explanation which has been given of cirrhosis is then destitute of foundation. In cirrhosis, as I have shown in another place, there is neither atrophy of the red substance, nor hypertrophy of the yellow, but rather *atrophy* of the greater number of granules, with *hypertrophy* and yellow discolouration of the remainder.

† *Arrangement of the lobules.* [According to M. Kiernan, from whose paper in the *Phil. Trans.* for 1833 this and the succeeding notes on the structure of the liver are derived, the lobules (granules, *Cruveilhier*) of the human liver are many-sided bodies, flattened on one surface, called the base, and forming processes in every other direction; hence in a longitudinal section they present a foliated, and in a transverse section a polyhedral form. The bases of all the lobules (*c c, fig.* 166.) rest on certain branches of the hepatic vein, called *sub*-lobular veins (*h h*), whilst their other surfaces, surrounded by the capsular investments, are either in contact with those of the adjacent lobules, or appear on the outer surface of the liver, or in the portal canals (*g g, fig.* 165.), which contain the vena portæ, hepatic artery, and hepatic duct, or in those for the larger trunks (*h, fig.* 166.) of the hepatic vein. The intervals between the sides of the lobules are the interlobular *fissures*, and the points at which two or more of these meet are the interlobular *spaces*. The superficial lobules are imperfect, or more or less flattened on their exposed side.]

hepatic vena portæ (*p*, *fig.* 164.); and that these branches subdivide and spread into all parts of the liver, some forwards, and others backwards, but all following a transverse direction. The capsule of Glisson, as we have seen, is developed around this vein; so that in sections of the liver, the branches of the vena portæ can always be recognised by these two characters — a transverse direction, and the presence of the capsule.

Remains of the umbilical vein. We can easily conceive the arrangement of these remains, if we consider that in the fœtus, the umbilical vein (*u*, *fig.* 164*.), proceeds from the placenta to the longitudinal fissure of the liver; and at the point where this is intersected by the transverse fissure, divides into two branches, one of which, under the name of the ductus venosus (*d*), passes directly to the vena cava (*c*), at the point where it traverses the posterior border of the liver; while the other is continuous with the hepatic vena portæ (*p*), which, as we have seen, occupies the transverse fissure. The portion common to the umbilical and portal veins remains pervious in the adult; but it then belongs exclusively to the vena portæ. The ductus venosus then becomes a mere fibrous cord (*v*, *fig.* 164*.), as well as the trunk of the umbilical vein itself (*u*). It is not rare to find the trunk of the umbilical vein persistent in the adult, from an abnormal communication between it and the veins of the abdominal parietes. (See *Anat. Path.*, avec planches, liv. xvii. pl. 6.) No example has been recorded of a persistent ductus venosus.

Fig. 164.*



Arteries. The hepatic artery is a branch of the cœliac axis (*t*, *fig.* 154.), which also furnishes branches to the spleen and the stomach; and although a difference in the origin of an artery does not occasion any difference in the blood within it, yet this community of origin is not the less remarkable, for it seems to denote a community, a coincidence, or a connection of function. Moreover, as the nervous plexuses are supported upon the arteries, it follows that the nerves of the spleen, stomach, and liver, are derived from a common plexus, the cœliac. We frequently find a second hepatic artery arising from the superior mesenteric.

I must not omit to mention the smallness of the hepatic artery in comparison with the size and mass of the liver. In this respect few organs present so great a disproportion: compare for example the kidney and the renal artery, look at the muscles, and I may almost say at the bones. The small caliber of the hepatic artery enables us to determine *à priori*, that it cannot serve both for the nutrition of the organ and for the secretion of the bile. Lastly, it exactly follows the ramifications of the vena portæ and the biliary ducts, and the capsule of Glisson is common to it and to those two sets of vessels.

The hepatic veins. The hepatic veins, the efferent vessels of the liver, are not proportional to the size of the hepatic artery, but to that of the vena portæ. Proceeding from all points of the liver, and converging towards the fissure of the vena cava, the hepatic veins (*h h'*, *fig.* 164.), empty themselves into that vein (*c*), especially near the posterior border of the liver. It follows, therefore, that the direction of the hepatic veins and of their divisions is from before backwards, while that of the divisions of the vena portæ is transverse.* This direction, and the absence of the capsule of Glisson, on account of which the walls of these veins are directly adherent to the tissue of the liver, so that the veins themselves remain patent, while the sections of the vena portæ collapse, are the two characters by which the divisions of the hepatic veins

* At least in the principal trunks; for there are a great number of ramifications of the hepatic veins which pass transversely.

may be distinguished from those of the vena portæ, on simply inspecting a section of the liver. Do these anatomical differences between the two kinds of veins produce any difference in the mechanism of the circulation through them? And is the want of immediate connexion of the divisions of the vena portæ to the tissue of the liver, intended to permit them to contract so as to propel the blood? If we consider that the blood of the vena portæ proceeds from the trunk towards the branches, as in the arteries, we may conceive the advantages which must result from an anatomical arrangement, that would allow these vessels to exert a direct pressure upon the blood.

Another point of difference between the branches of the hepatic vein and of the vena portæ is, that the walls of the former are perforated by a multitude of extremely small openings or pores, which are the orifices of very small veins.

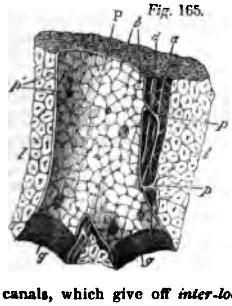
The lymphatic vessels. The lymphatics of the liver are so numerous that these vessels were first discovered in that organ; indeed, it was for a long time regarded as the origin of the lymphatic system, just as it had been originally considered the origin of the veins. The lymphatics of the liver form a *superficial* and a *deep* set. The superficial lymphatics are arranged in an extremely close network under the peritoneal coat. The deep set, which are very large and numerous, pass out of the transverse fissure of the liver, and terminate partly in lymphatic glands situated along the hepatic vessels, and partly in the lumbar glands. They communicate directly and freely with the thoracic duct, so that one of the best methods of injecting this duct, consists in throwing the injection into the lymphatics of the liver.

The nerves. These are very small, considering the size of the liver. They are derived from two sources, the cerebro-spinal and the ganglionic systems. The former are branches of the pneumogastric nerves; the latter constitute the hepatic plexus, which is an offset from the solar plexus. They are interlaced around the hepatic artery: some of these nerves however, by a special exception, accompany the vena portæ. It is generally admitted that a few filaments of the phrenic nerve are given to the liver.

The biliary ducts. Whatever may be the origin of the biliary ducts, their radicles, however small they may be, are always found in the capsule of Glisson, together with the corresponding branches of the vena portæ and hepatic artery. These radicles are united like veins into smaller, and these into larger branches, which at length constitute the *hepatic duct* (*d*, *fig.* 164.). They can be readily distinguished from the other vascular canals of the liver by their yellowish colour, by the fluid which they contain, and by the appearance of their parietes.*

* *Vessels.* [The first divisions of the vena portæ, hepatic artery, and hepatic duct, are situated in the portal canals, which are tubular passages formed in the tissue of the liver, commencing at the transverse fissure and branching through the substance of the organ. The smallest divisions of the portal canals contain one principal branch of each of these vessels (P *a d*, *fig.* 165.): from these proceed smaller branches called vaginal, from their situation within the capsule of Glisson.

Fig. 165.



In the larger canals the *vaginal veins* (*p'*) form a plexus in the substance of the capsule, and then give off the *inter*-lobular veins (*p p*) which pass between the lobules opposite the inter-lobular spaces, ramify in the inter-lobular fissures (*p p*, *fig.* 167.), and after freely anastomosing upon the capsular surfaces of the lobules, divide into branches which penetrate the lobules themselves. In the smaller portal canals the vaginal venous plexuses are less apparent, for many of the inter-lobular veins (*b*) arise at once from the principal branch of the vena portæ: where this occurs, the capsule of Glisson is very thin; and, indeed, the chief use of this structure, in other situations, appears to be to form a web, on which the vessels may ramify, so as to enter the liver at a great number of points, a use analogous to that of the pia mater and periosteum, in reference to the brain and bones.

The hepatic artery also forms *vaginal* plexuses in the portal canals, which give off *inter-lobular* branches; from these vessels the proper capsule of the

3. What is the *structure* of the *granules?* In examining a section of the liver of a pig with the simple microscope, I have seen most distinctly that each granule has a porous and spongy appearance, like the pith of the rush or elder, so that the proper tissue of the liver resembles a sort of filter. This appearance was much more distinct in livers which I had injected with walnut oil, either pure or coloured blue. The colouring matter thrown into the vena portæ was, as it were, infiltrated into the spongy tissue of the liver.

If we endeavour to ascertain the structure of the liver by means of injections, we shall see what was observed by Soemmering, that whichever vessel be injected, whether the hepatic artery, the duct, the vena portæ, or the hepatic vein (provided only the injection be thin, as for example coloured glue, size, or spirits of turpentine, or better still a strong aqueous solution of gamboge), there will not be a single granule into which the injection will not have penetrated; and moreover, that the liquid thrown into one vessel will pass either into one, two, or all three of the others; and the facility with which this takes place, proves that the different orders of vessels communicate with each other directly, and not through the medium of cells or small cavities.*

In a fœtus, or an infant that has died immediately after birth, an injection through the umbilical vein gives similar results. I have never been able to force the liquid into the lymphatic vessels, at least without rupturing the tissue of the liver. Air driven into the vessels penetrates more easily than liquids into the lymphatics, no doubt on account of its greater subtlety.

It follows, then, that in each granule there is an arterial radicle, a radicle of the vena portæ, one of the hepatic vein, and one of the duct, probably some lymphatic vessels, and a nervous filament. The aggregate has been represented by Soemmering as having some resemblance to the arrangement of a Damask rose.† All the different vessels communicate freely with each other.‡

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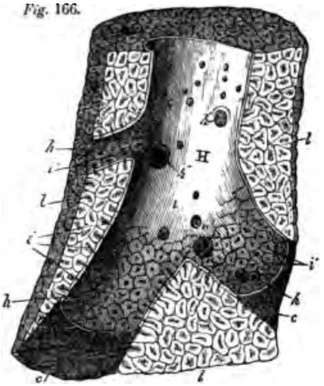
liver, the capsule of Glisson, the capsules of the lobules, and the coats of the different vessels, derive their nutrient arteries, which terminate in veins that enter the vena portæ. But few arterial branches enter the lobules themselves.

Fig. 166.



The hepatic duct also has its *vaginal* branches, but it is doubtful whether they anastomose; they are formed by the union of the inter-lobular branches (*d d*, *fig.* 168.), which do appear to anastomose, and are derived from the biliary ducts, which pass out at the surface of the lobules.

The several divisions of the hepatic veins are termed the hepatic venous trunks, the *sub*-lobular veins, and the *intra*-lobular veins. The *intra*-lobular veins (*i*, *fig*. 166.; *h*, *fig*. 167.), of which but *one*, independent of the rest, emerges from the centre of the base of each lobule, open into the sub-lobular veins (*h h*), through the thin walls of which can be seen the polyedral bases of the lobules, and the central orifices (*i' i'*) of the inter-lobular veins. This appearance is peculiar to the sub-lobular veins, the canals for which alone are formed by the bases (*c c*) of the lobules. The portal canals (*g*, *fig*. 165.) are formed by their capsular surfaces, and the openings (*b*) seen in the interior of the small divisions of the vena portæ, correspond to the inter-lobular spaces, not to the centres of the lobules. The sub-lobular veins anastomose with each other (this the divisions of the vena portæ never do), and unite to form the hepatic venous trunks (*H*, *fig*. 166.), into which no intra-lobular veins open, nor do the bases of any lobules rest upon them.]

* [From this statement the ducts must be excepted; they do not communicate with the blood-vessels. (See note, p. 524.)]

† "Quilibet acinus hepatis e glomeroso constat, vel e particulis arteriæ, venæ portarum, venæ hepaticæ, ductus biliferi et vasorum absorbentium, cujus formam rosæ sic dictæ Damascenæ imaginem pingere nobis licet." (*Corp. Hum. Fab.* t. vi. p. 180.)

‡ See note, p. 524.

The manner in which these different vessels are arranged in each granule can only be discovered by injecting them simultaneously, or rather successively, for it is nearly impossible to inject all the vessels of the liver at the same time. I have accordingly injected the vessels in the following order:— the vena cava, and consequently the hepatic veins, with wax coloured with Prussian blue—a certain quantity of walnut oil, also containing Prussian blue, had been previously thrown into the same vein; the vena portæ with a red injection; the hepatic artery with the same; and then the hepatic duct with a yellow injection. These injections were made in the liver of a pig, the liver being placed in warm water, and the injections pushed in with a gradually increasing force. During the injection of the vena cava and vena portæ, the wrinkles of the liver disappeared, and the central depressions of the superficial granules became, on the contrary, slightly prominent. It was therefore evident that each granule was hollow, and that the space had been filled by the injected matter.

The liver thus injected and submitted to different chemical agents gave the following results:—The blue injection, or that which had been thrown into the vena cava, had penetrated into the central part of each granule, which is generally called the yellow substance of the liver. In the middle of the central part was the yellow injection from the hepatic duct. Around the blue injection was found that coloured red, which had been forced into the vena portæ and the hepatic artery, and which occupied all the so-called red substance of the liver. It follows, therefore, that each granule had a vascular apparatus thus arranged: in the centre, a biliary duct; further removed from the centre, a vascular circle formed by the ramifications of the hepatic vein; and external to this another vascular circle, formed by ramifications of the vena portæ and hepatic artery. As to the manner in which the vena portæ and hepatic artery are arranged in relation to each other, we shall find, if we trace them into the substance of the liver, that the ramifications of the hepatic artery correspond exactly to those of the vena portæ and biliary duct, which, as we have already said, are all contained in the same sheath; and that they ramify and are lost upon the parietes of the vein and duct, almost in the same manner as the bronchial arteries are distributed upon the divisions of the air tubes. I must therefore conclude that the hepatic artery furnishes for the liver the nutritious vessels (*vasa vasorum*) of the vena portæ and hepatic ducts; and this will explain the disproportion between its caliber and the size of the liver.

The subdivisions of the hepatic veins, which follow a separate course, present a similar peculiarity to that observed in the splenic vein, viz. a multitude of pores or holes, by which very small veins open directly into them. Their ramifications are much less numerous than those of the vena portæ.

The result of the injections described above also explains the difference in colour between the centre and the circumference of each granule; it shows, moreover, that one part of the granule is impermeable to injections; and its spongy nature, resembling that of the pith of the rush or elder, is apparent even to the naked eye, in a section of a liver thus injected, when viewed by a strong light.

To resume, then, it may be said, that the liver is composed of ovoid, elliptical, or rather polyhedral granules, moulded closely upon each other. Each granule has its proper fibrous capsule; and all the capsules are united together by prolongations, which also connect them with the general cellular investment of the liver, and with that extension of it called the capsule of Glisson. The granules are independent of each other. Each of them consists of a spongy tissue, impermeable to injections; of a biliary duct proceeding from its centre; of a venous network formed by the hepatic veins; of another venous network belonging to the vena portæ; and of a very delicate arterial network derived from the hepatic artery, which is ramified upon the parietes of the vena portæ and biliary ducts. Such is the structure of the liver.* It remains for me now to examine its excretory apparatus.

The Excretory Apparatus of the Liver.

The excretory apparatus of the liver consists of the hepatic duct, of the cystic duct, of the gall bladder, and of the ductus communis choledochus.

The *hepato-cystic* canals †, admitted by some authors as constant or occasional in man, can be easily shown in the lower animals, but do not exist in the human species.

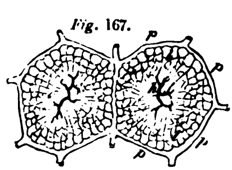
The hepatic duct. The hepatic duct arises in the granules of the liver by *hepatic radicles* ‡, which, by uniting successively like veins, constitute small and then larger branches. These latter all converge towards the transverse fissure of the liver, where they terminate ultimately in two trunks of almost equal size, which join each other at a very obtuse angle, and form the hepatic duct (*d, fig.* 164.). The condition of the branches of the hepatic duct in the transverse fissure is extremely variable: thus, sometimes the trunk of the right side is larger than that of the left, and sometimes the opposite is the case. Frequently several branches join the trunks late in the transverse fissure; but whatever be the nature of these variations, the right trunk never corresponds exactly to the right lobe of the liver, nor the left to the left lobe.

All the divisions and subdivisions of the hepatic duct § are contained in the

* *Structure of the lobules.* [It appears from the preceding note, that whilst several branches of the vena portæ and hepatic artery enter, and several of those of the hepatic duct pass out at the capsular surface of each lobule, only a single branch of the hepatic vein emerges from its base: within the lobules, the following is the arrangement of these vessels:—

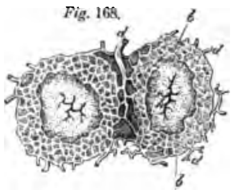
The branches from the interlobular (portal) veins (*p p p, fig.* 167.) form in the outer portion of each lobule a venous plexus (*l l*), consisting of branches radiating towards the centre, connected by others passing transversely: these veins become capillary, ramify upon the biliary ducts, and terminating in the branches of the intra-lobular (hepatic) vein (*h*), which correspond in number with the processes on the surface of the lobule, ultimately unite to form the central vein that passes out at its base.

Fig. 167.



The lobular arteries are few in number, and, according to Kiernan, end in branches of the vena portæ, and not directly in those of the hepatic vein. Müller inclines to the more commonly received opinion, that the three kinds of bloodvessels communicate with each other. No communication however exists, as stated by M. Cruveilhier, between the bloodvessels and the biliary ducts, which like the ducts of other glands, are an independent system of vessels. According to Mr. Kiernan the ducts form a reticulated plexus, occupying principally the outer portion of each lobule (as shown at *b b, fig.* 168., which is a diagram copied from Mr. Kiernan's paper). Müller expresses doubts as to the anastomosis of the ducts, and thinks it probable, from analogical observation, that they terminate in tufts of tubes having blind extremities.

Fig. 168.



The islets formed between the radiating and transverse branches of the lobular (portal) veins (*l, fig.* 167.), correspond to the acini of Malpighi, and contain the biliary ducts with their capillary bloodvessels, and also a peculiar tissue, which occupies all the intervals between the several kinds of vessels, and consists, according to Krause, of hexagonal nucleated cells, having several bright points in them, like globules of oily matter.

The appearance of two substances in the liver can now be explained; it does not depend on the biliary ducts being situated in the centre, and the veins nearer to the circumference of each lobule (see p. 518. 523.), but in a partial congestion of either the portal or hepatic system of veins.

In portal congestion the margins of the lobules are dark, and their centres pale; it is very rare, and has been seen only in children.

Of hepatic venous congestion there are two stages; in the first the centre of each lobule is dark, and the margin pale (*fig.* 166.); it constitutes passive congestion, and is the common state of the liver after death: in the second the congestion extends to the portal veins in the inter-lobular *fissures*, but not to those in the interlobular *spaces*, or points at which those fissures meet, which spaces are then seen to occupy the centre of each pale isolated spot: this is active congestion of the liver; it occurs in diseases of the heart, and in acute diseases of the lungs and pleura.]

† [*I. e.* canals passing directly from the liver into the gall bladder.]

‡ See note, *suprà*.

§ [Excepting those within the lobules.]

capsule of Glisson, together with the ramifications of the vena portæ and hepatic artery, to which they are connected by loose cellular tissue. The trunks of the hepatic duct lie at the bottom of the transverse fissure, and are hid by the trunk of the vena portæ and the branches of the hepatic artery. The hepatic duct (*t*, *fig.* 169.), thus formed by the union of the two trunks which occupy the transverse fissure, passes downwards and to the right side for about an inch and a half, and then unites at a very acute angle with the cystic duct (*s*), to form the ductus communis choledochus (*c*; and *x*, *fig.* 154.). In this course the duct is contained in the gastro-hepatic omentum, together with the vena portæ which is behind it, and the right branch of the hepatic artery which is in front of it. A great quantity of loose cellular tissue unites the duct to these vessels.

The gall bladder. Dissection. A gall bladder filled with bile may be studied without any preparation: if it is empty it must be distended, either with a fluid or with air. A beautiful preparation of the gall bladder may be made for preservation by drying it after inflation, or by filling it with fat, which is afterwards removed by oil of turpentine.

The gall bladder (*cystis fellea*, *g*, *fig.* 164.) is the reservoir of the bile. It is situated at the lower surface of the right lobe of the liver, occupying a particular fossa (the fossa of the gall bladder) on the right of the longitudinal fissure, from which it is separated by the lobulus quadratus. It is held in this place by the peritoneum, which, in the majority of instances, merely passes below it, but, in others, almost entirely invests it, and thus attaches it to the liver by a sort of mesentery. In this latter case it is at some distance from the liver, as in certain animals.

Its *form* is that of a pear, or of a cone with a rounded base; it is directed obliquely, so that its great extremity (*g*, *figs.* 155. 161.) looks forwards, downwards, and to the right; and its small extremity, backwards, upwards, and to the left side.

Size. The small size of the gall bladder corresponds with that of the rest of the excretory apparatus of the bile, and is strongly contrasted with the great bulk of the liver. This difference becomes still more striking if we compare, on the one hand, the kidney with the liver, and, on the other, the urinary bladder with the gall bladder. It is true, however, that all the urine must pass through the former, while a part only of the bile is deposited in the latter

The size of the gall bladder, however, is subject to considerable variety; it sometimes acquires three, four, or even ten times its usual size from retention of the bile, in consequence of obstruction in the ductus choledochus.* Cases have been recorded in which it contained six, eight, or ten pounds of bile, but this I can scarcely credit. On the other hand, it is sometimes closely contracted round a small calculus, whilst the cystic duct is completely obliterated, and reduced to a fibrous cord. It must undoubtedly have been such cases as these, that have been regarded as examples of congenital absence of the gall bladder.

Relations. In order to facilitate our description, we shall consider the gall bladder as consisting of a *body*, a *fundus*, and a *neck*.

The *body* is conical, and has the following relations:—*below*, where it is covered by the peritoneum, it is in relation with the first portion of the duodenum, and the right extremity of the arch of the colon. It is not unfrequently found in contact with the pylorus, or even with the pyloric end of the stomach. Sometimes it is united by accidental or normal adhesions to the duodenum and arch of the colon. These relations account for the yellow or green discolouration which always takes place after death in those parts of the alimentary

* Another cause of enlargement of the gall blader is the obstruction of its neck by a calculus; but instead of bile, it then contains a limpid serum, and in fact is converted into a serous cyst. The tumour thus formed may be compared to the lachrymal tumour in cases of obstruction of the lachrymal puncta or canals.

canal that are in contact with the gall bladder; and also for the passage of biliary calculi into the duodenum, the colon, and the stomach. It is not very rare to find the gall bladder applied by its whole length to the right kidney: this relation can only occur after descent of the duodenum and transverse colon. *Above*, the body of the gall bladder adheres to the cystic fossa by a more or less loose cellular tissue *, and by arteries and veins, but never in the human subject by biliary, *i. e.* hepato-cystic, ducts.

The *fundus* of the gall bladder (*g*, *fig.* 161.), entirely covered by the peritoneum, generally projects beyond the anterior margin of the liver, and comes into relation with the abdominal parietes, opposite the outer border of the right rectus muscle, immediately below the costal cartilages near the anterior extremity of the tenth rib. When distended with bile or calculi, the fundus of the gall bladder becomes prominent, so as to raise the abdominal parietes, through which it has been felt in emaciated individuals. It has even been stated that the noise made by the calculi may be heard on percussion. This relation explains the possibility of the occurrence of abdominal biliary fistulæ, and why calculi may escape through such openings: on it also is founded the scheme for extracting the calculi by an operation analogous to that performed for stone in the urinary bladder, and which I should not have mentioned had it not been proposed by J. L. Petit.

The relations as well as the size of the fundus of the gall bladder present many varieties. The fundus, or that part which projects beyond the liver, is sometimes as large as the body. I have seen this part of the gall bladder turned back at a right angle upon its body, and reaching the umbilicus. It may be conceived that the differences in the form and situation of the liver must greatly influence the situation of the fundus of the gall bladder, which I have found in the hypogastrium and in the right iliac fossa, either with or without adhesion to the neighbouring parts.

The *neck* or apex of the gall bladder is twice bent suddenly upon itself, like an italic *S*, having its three portions in contact. It would appear, in some cases, that these two curves resemble the thread of a screw. This double curvature may be easily effaced by removing the peritoneum with the subjacent cellular tissue. The limits between the neck and the body of the gall bladder on the one hand, and between the neck and the cystic duct on the other, are marked externally by a constriction.

The *internal surface of the gall bladder* is tinged either green or yellow, according to the colour of the bile; but this staining is the effect of transudation after death: its natural colour is a whitish grey. Moreover, the internal surface is irregular, like shagreen, and has some crests or prominences arranged upon it in polygons, and again subdivided by smaller crests, like the reticulum in the stomach of ruminantia; so that when examined by a strong lens, it appears divided into a number of small and very distinct alveoli : some highly developed papillæ or villi, of a very irregular shape, are also found upon it. As to the object of either the crests or the papillæ, or whether they favour absorption by multiplying the surface, we are altogether unable to decide.

Opposite each of the two curves of the *S*, described by the neck of the gall bladder, we find a very large valve. The two valves, which are in opposite directions, as well as the curves, result from the alternate inflection of the neck itself, and are effaced by straightening that part. The portion of the neck between the two valves is not unfrequently dilated into an ampulla. A calculus is often formed in this intermediate portion, where it remains as it were encysted, and intercepts the course of the bile; and that the more easily, because the valves greatly contract the openings from the neck into the body of the

* This cellular tissue may become inflamed, and if pus be formed, it may pass into the gall bladder, whilst the bile escapes into the cellular tissue, and hence death may ensue. I have observed in a very short space of time three examples of this lesion, which perhaps has not been thoroughly examined; and several cases have been shown me under the name of gangrene of the gall bladder.

bladder, and into the cystic duct. Moreover, these valves are opposed neither to the entrance of the bile into, nor to its exit from, the bladder.

Structure. Proceeding from without inwards, we find that the gall bladder is composed of, 1. a *peritoneal* coat, which is reflected from the lower surface of the liver upon the bladder, completely invests its fundus, forms a more or less incomplete covering for its body and neck, and is continuous with the anterior layer of the gastro-hepatic omentum. 2. An areolar *fibrous coat,* which forms as it were the framework of the bladder, and prevents its sudden distension, though it will yield to a long-continued distending force; but I have not been able to see the muscular fibres admitted by some authors, and which can be so easily demonstrated in the larger animals, the ox in particular. 3. An *internal mucous membrane,* the principal characters of which I have noticed when speaking of the internal surface of the gall bladder: it presents some folds, which may be easily distinguished from the borders of the alveoli, because they are readily effaced by distension. After the most attentive examination, I have been unable to recognise any crypts or follicles.

The gall bladder receives one very considerable artery, the *cystic branch* of the hepatic. The *cystic vein* terminates in the vena portæ. The lymphatic vessels are very numerous and easily demonstrated; they are sometimes tinged by the colouring matter of the bile. Its nerves are derived from the hepatic plexus.

The cystic duct. The cystic duct (*s*, *fig.* 169.), or excretory duct for the bile, is the smallest of all the biliary canals: it is not uncommon, however, to find it of an equal or even larger size than the others; in which case there has always been some obstacle to the flow of the bile through the ductus communis choledochus (*c*). It commences at the neck of the gall bladder, passes downwards and to the left side for about an inch, and unites at a very acute angle with the hepatic duct (*t*).

It is not straight, but inflected, and, as it were, sinuous.

Relations. It is situated in the substance of the gastro-hepatic omentum, in front of the vena cava, the cystic artery being on its left side. Its *internal surface* is remarkable for its *valves,* which are indefinite in number; according to Soemmering there are from nine to twenty, but this appears to me to be an exaggeration; I have counted from five to twelve. These valves are concave at their free margins, irregular, alternate, oblique, transverse, sometimes even vertical, and united together by small oblique valves. In order to understand their structure, a cystic duct must be examined under water, or rather an inflated and dried specimen. This alternate arrangement of the valves, sometimes gives a spiral appearance to the inner surface of the cystic duct.* These valves, which only exist in man, perhaps on account of the erect position peculiar to him, are not effaced, like the valves in the neck of the gall bladder, by such dissection as will allow of straightening of the duct. Small calculi are occasionally met with in the intervals between the valves, giving to the cystic duct a nodulated appearance, and intercepting the flow of the bile. Moreover, the valves of the cystic duct are not more opposed to the descent than to the ascent of the bile. It is even probable that they facilitate the ascent of the bile into the gall bladder by supporting the column of liquid, like the valves of the veins. Perhaps they are also intended to retard the course of the bile from the gall bladder towards the ductus choledochus. From their appearing sometimes to have a spiral arrangement, M. Amussat has advanced a very ingenious opinion — that the ascent of the bile is effected by a contrivance like an Archimedes' screw. But an Archimedes' screw only causes the ascent of a liquid when a rotatory movement is communicated to it, and how can such a movement be performed by the cystic duct? †

* "Quæ possint aliquam spiralis fabricæ imaginem ferre." (*Haller*, tom. vi. liv. xxiii. p. 530.)

† Another opinion, founded upon the existence of the valves, is that of Bachius, who, believing that he had shown that the valves prevent the ascent of the bile from the hepatic duct

The ductus communis choledochus. The ductus communis choledochus (χολὴ, bile, δοχὸς, containing; *c c*, *fig.* 169.) the last excretory canal of the bile, seems to be formed by the union of the hepatic (*t*) and the cystic ducts (*s*). Another, and perhaps more simple, manner of viewing the excretory canals of the liver would be to consider the hepatic duct as giving off to the right, after a certain course, the cystic duct, which, after passing backwards, dilates into an oval ampulla to form the gall bladder; and the ductus choledochus as nothing more than the continuation of the hepatic duct.

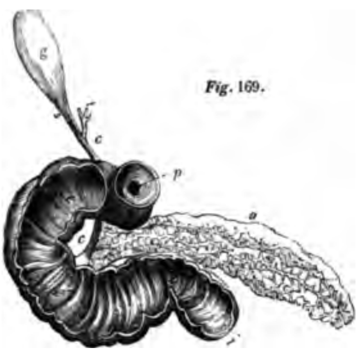


Fig. 169.

The *direction* of the ductus choledochus is in fact the same as that of the hepatic duct, *i. e.* obliquely downwards, a little to the right, and backwards: there is no line of demarcation between these two ducts: in the natural state there is no marked difference in their diameters: the ductus choledochus, when collapsed, is about as large as a moderately sized goosequill. The same causes give rise to dilatation of the ductus choledochus and of the hepatic duct. I have seen the former as large as the duodenum. (*Anat. Pathol.* avec planches.) Its *length* is from two to two inches and a half.

Relations. In the first part of its course, before it reaches the duodenum, the ductus choledochus is included in the gastro-hepatic omentum, in front of the vena portæ, and below the hepatic artery, having the right gastro-epiploic artery along its left side, and surrounded by loose cellular tissue, a great number of lymphatic vessels, and several lymphatic glands. Having reached the duodenum, opposite the first flexure of that intestine, it passes behind and to the inner side of its second portion, and is there received into a groove, or more commonly into a complete canal, formed for it by the pancreas.

Lastly, it penetrates very obliquely into the substance of the duodenum, about the middle of its second or vertical portion, perforates the muscular coat, passes between that and the fibrous coat, then between the fibrous coat and the mucous membrane, elevating the latter when distended with bile or by a probe, and after a course of about seven or eight lines between the coats, opens into the duodenum, about the lower part of the second portion, at the summit of a nipple-like eminence (above *e'*), which is more or less prominent in different subjects.

In this third portion of its course the ductus choledochus is in relation with the pancreatic duct (*u*), which is situated on its left. Opposite the base of the eminence above mentioned, the two ducts unite, or rather the pancreatic duct opens into the ductus choledochus; so that, at its termination, the latter may be regarded as a canal having a triple origin, viz. an hepatic, a cystic, and a pancreatic.*

into the gall bladder, has advanced very singular views concerning the formation and uses of the bile. The bile, according to him, is formed in the gall bladder, and carried by the cystic duct into the hepatic duct and the ductus choledochus. By his theory, the bile which reaches the liver through the hepatic duct, assists greatly in sanguification. This opinion, altogether erroneous as it is, has perhaps exercised a great influence in science, by contributing to eradicate the idea of the bile being an acrid, corrosive, and essentially injurious, excrementitial fluid.

* Hence the definition of Soemmering: "*Ductus choledochus, id est, ductus hepaticus, cysticus, et pancreaticus, in unum conflati.*" (*Corpor. Hum. Fabric.* tom. vi. p. 186.)

Internal surface of the ductus hepaticus and ductus choledochus. The internal surface of both the hepatic duct and the ductus choledochus is characterised by the absence of valves, though traces of valves are occasionally met with in the ductus choledochus; by the absence of the alveolar structure observed in the gall bladder; and by having a multitude of openings or well marked pores, which are considered as belonging to muciparous follicles, and are apparently formed by an interlacement of fasciculi, having a fibrous character, and intersecting each other at very acute angles. The ductus choledochus and the hepatic duct are of uniform caliber throughout their whole length. The ductus choledochus is contracted a little in its third or duodenal portion; it dilates into an olive-shaped ampulla, opposite the base of the papilla in the duodenum, and opens by an extremely small orifice or mouth: hence the reason why biliary calculi are so frequently arrested in the ampulla of the ductus choledochus.

From the narrowness of the duodenal orifice of the ductus choledochus, from the moveable or yielding nature of the eminence upon which it opens, and from the oblique course of the duct through the substance of the walls of the duodenum, it follows that the bile and the pancreatic fluid may pass freely from the ductus choledochus into the duodenum, but cannot regurgitate from the duodenum into the duct. On this subject I have made several experiments. I have forcibly injected both water and air into the duodenum, included between two ligatures, but nothing entered into the biliary canals: on the other hand, I have injected the same fluids from the gall bladder into the duodenum, which I was thus able to distend at pleasure. But then, on compressing the bowel thus distended with great force, I have never been able to cause the slightest reflux into the biliary canals.*

At the union of the cystic and hepatic ducts there is a very long spur-shaped process, formed by the lining membrane reflected upon itself. At the junction of the ductus choledochus and the pancreatic duct there is also a similar process, which I have seen extending down to the duodenal orifice. In neither situation do these processes prevent the fluid of one canal from passing into the other. Thus, the cystic bile might flow back into the hepatic duct, the pancreatic fluid might regurgitate into the ductus choledochus, and on the other hand the bile might enter the pancreatic duct, if these canals were not habitually full. Moreover, the spur-shaped process, between the ductus choledochus and the pancreatic canal, cannot arrest the flow, either of the bile or the pancreatic fluid, by being applied to the orifice of the one or other duct.

Structure of the biliary ducts. All the biliary ducts have a similar structure: they have an internal *mucous* membrane, continuous on the one hand with the lining membrane of the gall bladder, and on the other with that of the duodenum; it is thin, and provided with slightly developed papillæ †; a *proper membrane*, composed of a dense areolar tissue, generally regarded as fibrous, but which appears to me analogous to the tissue of the dartos condensed; a cellular layer connecting these canals to the surrounding parts; and lastly the peritoneum, which forms a very incomplete accessory tunic for them.

Thus constituted, the biliary ducts have very thin walls, so that they collapse like veins, and are extremely dilatable. In certain cases of retention of the bile we find the ductus choledochus and the hepatic duct as large as the duodenum, the divisions of the hepatic duct dilated in proportion, and the

* How can this fact be reconciled with another no less incontestable, viz. the passage of lumbrici into the biliary ducts? The reason is, that the lumbricus is a foreign body, which has a power of selection, and is able to overcome an obstacle, to seek for the orifice of the ductus choledochus, and to introduce itself within it.

† [Numerous follicles are found in the ductus communis and in the hepatic duct, and all its subdivisions; according to Mr. Kiernan, even in the smallest that can be examined. In the larger branches they are arranged irregularly; in the smaller ones, in two longitudinal rows, along opposite sides of the duct.]

tissue of the liver more or less atrophied by the compression to which it has been subjected.

Developement of the liver. The developement of the liver is one of the most important subjects in its history. Under this head we have several points to consider: —

1. The *time of its appearance* is anterior to that of any other organ *: in the first days of intra-uterine life it may be distinguished by its colour in the midst of the cellular mass which represents the fœtus.

2. In *size* the liver is relatively larger as it is examined at an earlier period of developement. Thus, according to Walter, in the embryo of three weeks it forms one half the weight of the whole body. This enormous proportion is maintained during the first half of intra-uterine life. After this period its growth is slower, while that of the other organs is proportionally increased, so that at birth the weight of the liver is one eighteenth that of the whole body. † After birth the liver undergoes an absolute diminution; some authors have even affirmed that a comparison of the weight of the liver in new-born infants and in children of nine or ten months old, gives a difference of one fourth in favour of the former. It is generally said that the difference in size affects the left rather than the right lobe; but this has not appeared evident to me. Towards the age of puberty the liver has the same relative bulk as at later periods. Attempts have been made to ascertain the proportion between the weight of this organ and that of the body, and it has been said that it forms one-thirty sixth part of the whole body. But what relation can be established between two terms, one of which, viz. the weight of the body, is subject to continual variations? In old age the liver is smaller than in the adult, a diminution apparently in unison with that which occurs in all the other organs.

3. The *differences in the situation* of the liver are connected with its variations in size: thus, in the first half of intra-uterine life, the liver occupies the greatest part of the abdomen, and is in relation with certain regions in which it is not found at more advanced stages. In the earliest periods it descends as low as the crest of the ilium, and when the abdomen is opened it presents the appearance of a red mass, beneath which are placed the other abdominal viscera. During the second half of intra-uterine life and at birth it occupies only a part of the abdomen; but it still corresponds to a considerable extent of the abdominal parietes: hence the ease with which it is ruptured by pressure upon the abdomen of a new-born infant. One fact, on record, seemed to me to prove, that in a first labour, where the feet presented, the pressure of the genital organs of the mother was sufficient to produce this result. (Vide *Procès-verbal de la Distribution des Prix de la Maternité*, 1832.)

In the earliest periods the falciform ligament of the liver corresponds to the median line of the body; at birth it is a little to the right of that line, and is afterwards removed still further in the same direction.

4. The great size of the liver during intra-uterine life is connected with the existence of the *umbilical vein*, by which the fœtus receives the blood returned from the placenta, that is to say, all the blood necessary for its nutrition. The rapid diminution of the liver after birth is probably owing to the obliteration of this vein. It is a very remarkable fact, that the persistence of this vein in the adult is not accompanied by an unusually large liver. In one particular case of persistence of the umbilical vein the liver was of a very small size. (*Anat. Path.* avec planches, liv. xvii.)

* [In the embryo of the bird the liver is developed by a conical protrusion of the walls of the intestinal canal into a granular mass or blastema. (See *Müller's Phys.* by Baly, p. 448.) The rudiments of the cerebro-spinal axis, of the heart and of the intestinal canal appear previously to the liver.]

† I have had occasion to notice at the Maternité, the very great differences in the size of the liver in infants at birth, for which I have been unable to find any sufficient reason. There are some well formed infants in whom the liver at birth is not relatively larger than that of adults.

5. The tissue of the liver of the fœtus is of a pale red colour in the early periods, and of a deep brown near the full term of pregnancy; its colour becomes lighter after birth. The liver contains a greater quantity of blood before than after birth. Its tissue is the less consistent, the earlier the stage of developement at which we examine it, and its softness is accompanied with great fragility.

6. The distinction between what are called the two substances of the liver is not appreciable during intra-uterine life. It only becomes apparent after birth.

Functions. The liver is the secreting organ of the bile. The bile is secreted in the glandular granules by an unknown process. Doubts are still entertained as to whether the materials from which the secretion is formed are conveyed by the hepatic artery or the vena portæ.* The opinion advanced by some modern authors, that the yellow substance of the liver is the only part concerned in the secretion of the bile, and that the brown substance has other uses, is a purely gratuitous hypothesis.

The bile traverses the several ramifications of the hepatic duct, and having arrived in the principal duct, it may either enter directly into the duodenum by the ductus choledochus, or it may pass into the gall bladder by the cystic duct. This retrograde movement towards the gall bladder has much occupied the attention of physiologists: perhaps it may be explained by the narrowness of the duodenal orifice of the ductus choledochus, by the elasticity of that canal, and especially by the pressure exercised on its duodenal portion by the circular fibres of the duodenum. The gall bladder and the cystic duct are not indispensable to the elimination of the bile. Nothing is more common than to find the excretory apparatus of the liver in old subjects reduced to the hepatic duct and the ductus choledochus.

Has the liver any other function besides that of secreting bile? The disproportion existing between the size of that organ and of its excretory apparatus, and also the enormous bulk of the liver during fœtal life, *i. e.* at a time when the secretion of bile is at its minimum of activity, are both in favour of the opinion that the liver has some additional function; and if again we consider that in the adult a very important system of veins is distributed to the liver, and that in the fœtus it receives the blood from the veins of the fœtal portion of the placenta, we shall be led to presume that the unknown functions of this organ are in some way connected with the process of sanguification.

The Pancreas.

Dissection. The pancreas may be seen, through the gastro-hepatic omentum, after drawing down the stomach, without any dissection. In order to expose it, turn the stomach upwards (see *fig.* 154.), after having divided the two layers of peritoneum which proceed from its greater curvature to form the great omentum. It may also be exposed by turning the arch of the colon upwards, and dividing the inferior layer of the transverse mesocolon. The excretory duct is situated in the interior of the organ. In order to dissect it, the glandular substance which covers it must be very carefully removed, towards the middle and the right extremity of the gland. It may be injected from the ductus choledochus, after the vertical portion of the duodenum has been included between two ligatures: when the duodenum is filled with the injection, the pancreatic duct becomes filled in its turn. It may also be injected from the ductus choledochus after having passed a ligature round the projection or ampulla which is common to the two ducts.

The *pancreas* (πᾶν-κρέας, all flesh) is a glandular organ annexed to the

* [From the researches of Mr. Kiernan (see note p. 524.) it would appear, that the blood of the vena portæ is *directly* concerned in the secretion of the bile, whilst that of the hepatic artery is only *indirectly* concerned, *i. e.* after it has afforded nutrition to the tissue and vessels of the liver, and has entered the branches of the vena portæ, and thus become portal blood.]

duodenum, with which it has immediate relations: it is situated transversely and deeply behind the stomach, and in front of the lumbar vertebræ.

Form and size. In form the pancreas resembles no other gland; it is transversely oblong, flattened from before backwards, large at its right extremity, where it presents a sort of angular expansion like a hammer, and gradually tapering towards its left extremity: hence the division of this organ into a *head*, *body*, and *tail.* Its long or transverse diameter is measured by the interval between the concavity of the duodenum (*e e*) and the spleen (*k*). The size and weight of the pancreas present many varieties. Its weight is generally from two to two and a half ounces, but may reach six ounces. The pancreas is sometimes found atrophied, and in one case of this kind it did not exceed an ounce in weight.

Relations. Its *anterior surface*, convex and covered by the peritoneum, is in relation with the stomach, which moves freely upon it. In certain cases of disease, adhesion between the pancreas and the stomach takes place; so that in chronic ulceration of the latter we find the pancreas supplying the place of large portions of the walls of the stomach which had been destroyed. When the stomach is situated lower down than usual, the pancreas has relations either with the liver, or with the anterior walls of the abdomen, from which it is separated only by the gastro-hepatic omentum; so that it may be felt with the greatest ease through the abdominal parietes.* In such cases even experienced practitioners have not unfrequently been led to infer the presence of scirrhus of the pylorus. The pancreas is also in relation in front with the first portion of the duodenum, and with the angle formed by the ascending and transverse colon.

Its *posterior surface* is concave, and corresponds to the vertebral column, opposite the first lumbar vertebra: it is separated from the spine, however, by the splenic and the superior mesenteric veins, and by the commencement of the vena portæ. The two last mentioned veins are lodged in a deep groove, or rather almost complete canal, formed in the pancreas, which also includes the superior mesenteric artery and its surrounding plexus of nerves. A great number of lymphatic vessels and glands, the pillars of the diaphragm (*d d*), the vena cava on the right side, and the aorta on the left, also separate the pancreas from the vertebral column. To the left of the spine it is in relation with the left suprarenal capsule and kidney, and the corresponding renal vessels. The relation of the pancreas to the aorta is important; it is through the pancreas that the pulsations of that vessel are felt in the epigastrium, in emaciated individuals, and it is here that the vessel may be compressed.

Its *upper border* is thick, and is grooved for the reception of the splenic artery, which often runs in a sort of hollow canal formed in the substance of the gland through its entire length. It also has relations with the first portion of the duodenum (*e*), with the lobulus Spigelii, and with the cœliac axis (*t*). The thickness of this border has led some anatomists to say, that the pancreas is prismatic and triangular.

Its *lower border* is much thinner than the upper, and is bounded by the third portion of the duodenum, from which it is separated on the left by the superior mesenteric vessels (*m*, the artery).

Its *right*, or *duodenal*, or *great extremity* is in contact with the duodenum and the ductus choledochus. This extremity presents a very remarkable arrangement; it is curved upon itself from above downwards, like the duodenum, by the concavity of which it is circumscribed; then, having reached the third portion of the bowel, it passes transversely to the left, behind the superior mesenteric vessels, and forms the posterior wall of the canal in which they are

* This condition may be foretold: it occurs whenever the vertebral column can be felt immediately behind the parietes of the abdomen. I have never met with it excepting in emaciated individuals, where a great part of the small intestine occupied the cavity of the pelvis. It is probably the traction exercised by the small intestine contained in the pelvis, that occasions the low position of the stomach.

situated. This reflected portion, arranged in the form of a whorl, is sometimes detached from the rest of the gland, on which account it has been called the *lesser pancreas*. By its great extremity the pancreas is, as it were, attached to the duodenum, beyond which it projects in front, but especially behind: it accompanies this intestine in all its displacements, so that when the duodenum is situated lower down than usual, which happens in displacements of the stomach downwards, the head of the pancreas is always removed in the same direction.

Its *left*, or *splenic*, or *small extremity* is narrow, and touches the spleen, upon which it is flattened and blunted, and sometimes slightly enlarged. It is seen then, that, in its relations to other parts, the pancreas has a great analogy with the salivary glands. Thus, large vessels are situated near and penetrate this gland, which forms a sort of covered passage for them, and is moved by their pulsations. The diaphragm, the duodenum, and the stomach also tend to disturb and press upon the pancreas.

Structure. The analogies in structure between the pancreas and the salivary glands are no less numerous, and fully justify the name of *abdominal salivary gland* given to it by Siebold; it has the same whitish colour, the same density*, and the same arrangement into lobes, which are themselves divisible into lobules. The identity is such that it would be impossible to distinguish a portion of the pancreas from a part of a salivary gland. When boiled, they both have the same aspect and the same taste. There is no fibrous capsule, properly so called, but some fibrous lamellæ, which separate the lobes and lobules. Cellular tissue is tolerably abundant. Fat is not uncommonly met with, either on the surface or in the substance of the pancreas; I have even seen cases of atrophy of the gland, in which fat appeared to have been substituted for the glandular substance.

The determination of the structure of the pancreas, like that of all glands, involves two considerations, viz. the texture of each lobule, and the arrangement of the vessels and nerves in the substance of the gland. With regard to the first point, I shall merely refer to what has been already stated respecting the salivary glands.† The arrangement of the *vessels* is perfectly well known.

As in the salivary glands, the *arteries* enter the pancreas at a great number of points. They are very numerous and very large, considering the small size of the organ: they arise from the hepatic, the splenic, and the superior mesenteric. The principal artery is called the pancreatico-duodenalis.

The *veins* terminate in the superior mesenteric and the splenic. The *lymphatic vessels* are not well known; it is probable that they enter the numerous glands which are in the neighbourhood. The *nerves* of the pancreas are derived from the solar plexus.

The *excretory duct* (*u*, *fig.* 169.) is called the *canal of Wirsung*, from the name of its discoverer, a young anatomist, who was too soon lost to science. By an arrangement, of which we have no other example in the body, this excretory duct is contained entirely in the substance, we might even say in the centre of the gland; so that, in order to expose it, the superficial portion of the organ must be carefully divided. It is generally single, but sometimes double, and then there is a principal duct belonging to the body of the pancreas, and a small duct for the reflected portion, or lesser pancreas. The pancreatic duct measures the entire length of the gland; it is narrow at the splenic extremity, which may be regarded as its origin, and gradually increases in size as it approaches the duodenal extremity; there it bends downwards, to reach the ductus choledochus, to the left of which it is placed; it runs along the side

* The pancreas sometimes assumes an extreme density, strongly resembling that of scirrhus. In such a case it is necessary to make sections of it, to be assured of the perfect soundness of the glandular tissue. This stony hardness generally occurs along with atrophy of the organ.

† [The only observable difference between the lobules of the pancreas and salivary glands is, that the closed termination of the ducts are cylindrical in the former, and slightly dilated in the latter, (see note, p. 450.).]

of that duct, then perforates it obliquely, and opens, as I have already described when speaking of the liver, in the olive-shaped ampulla immediately preceding the duodenal orifice of the ductus choledochus. It follows, therefore, that the pancreatic duct and the ductus choledochus open by a common orifice in the human subject. This arrangement is constant, and when we find a pancreatic duct perforating the duodenum separately, we may be certain that there is another duct presenting the regular arrangement; at least, I have never observed to the contrary. As to the precise situation of the separate opening of the supernumerary pancreatic duct, it may be either in front of, behind, below, or above, the orifice of the ductus choledochus. Tiedemann, who has collected all the known cases of double pancreatic duct, and all the varieties of insertion found in the human subject, has arrived at the curious result, that these varieties have their analogies in the different species of animals.

The mode in which the divisions of the pancreatic duct are inserted into the principal trunk deserves to be noticed. The ultimate ducts of the pancreas do not in fact unite into larger and larger branches like the veins; but the small branches coming from each lobule, open directly and in succession into the general duct — an arrangement which gives to the excretory apparatus of the pancreas the appearance of those insects called *centipedes*.

As to the structure of the pancreatic duct, its walls are very thin; it is collapsed, and of a milk-white colour, very distinct from the greyish white hue of the proper tissue of the gland. Its internal surface is extremely smooth, like a serous membrane *; its thinness renders the determination of its texture very difficult; it is very extensible.

Developement. The developement of the pancreas presents no peculiarities excepting such as relate to its size, which is relatively greater in the fœtus and the new-born infant than in the adult. Examples have occurred of disease of the pancreas during intra-uterine life; and I have found a scirrhous pancreas in a fœtus at the full term.

Function. The pancreas is the secreting organ of a particular fluid called the pancreatic fluid, the physical and chemical characters of which have not been well known until very lately. I have met with two cases of retention of the pancreatic fluid. The dilated canal resembled a transparent serous cyst; the contained liquid was extremely viscid and transparent, but of a whitish hue, like a solution of gum arabic; it had a slightly saline taste; the collateral ducts were extremely dilated. There were some white patches, resembling plaster, in the centre of many of the lobules. This substance was more abundant in some of the lobules, and, when removed, presented the appearance of small lumps of plaster or chalk. The pancreatic fluid submitted to chemical analysis by M. Barruel, proved to be an extremely pure mucus. M. Barruel even stated to me that it was the purest mucus he had ever examined. It possesses in the highest degree the property of rendering water viscid, either by dissolving, or by being diffused in it. This mucus contains free soda, a trace of chloride of sodium, and a very slight trace of phosphate of lime. There is therefore an analogy between the pancreatic and salivary fluids, as the anatomical investigation of these glands had previously led us to suppose.†

* [It is a mucous membrane, continuous with that of the duodenum, and covered with epithelium. In some subjects, Mr. Kiernan found mucous follicles in it, similar to those in the biliary ducts; in others, no traces of them could be discovered. None were seen in the salivary ducts.]

† [According to the best analyses, the pancreatic fluid differs from saliva in containing a greater amount of solid matter, and also in the character of its constituents: saliva is usually alkaline, and, besides other substances, contains salivine, mucus, and sulpho-cyanate of potassa; the pancreatic fluid contains albumen, casein, but little salivine and mucus, and no sulpho-cyanate: in other respects the two fluids agree.]

The Spleen.

The *spleen* (σπλὴν, lien; *k*, *fig.* 154.) is a spongy and vascular organ, the functions of which, though little known, appear to be connected with those of the abdominal venous system.

It is deeply situated (*k*, *figs.* 155. 161.) in the left hypochondrium, behind and to the left of the great end of the stomach, to which it is united by a fold of peritoneum, called the *gastro-splenic omentum.* It is also retained in its place by the peritoneum, which is reflected upon it from the diaphragm *, and by the vessels which enter and pass out from it. Being suspended rather than fixed to certain movable parts, the spleen necessarily participates in their movements; and the contraction or relaxation of the diaphragm, as well as the alternate distension and collapse of the stomach, exert an undoubted influence upon it; but these slight and temporary changes of position do not constitute a true displacement.

It may even be said, that displacements of the spleen, which are very rare, are almost always congenital. Thus Haller has seen this organ situated at the left side of the bladder, in an infant one year old; Desault has found it in the right cavity of the thorax in a fœtus at the full time, I do not here allude to cases of complete transposition of the viscera, nor to cases where the change of situation depends on enlargement of the spleen, or on displacement of the stomach. † I have mentioned elsewhere that I have found the spleen in the umbilical region.

Accidental adhesions of the spleen are so frequent, that they deserve to be mentioned. They are sometimes filamentous, and sometimes cellular, and they render painful the slightest changes of position in this organ, from violent contractions of the diaphragm, or from great distension of the stomach: these adhesions are almost always the sequelæ of intermittent fevers.

Number. The spleen is single in the human subject. The *supernumerary spleens* occasionally met with near it are nothing more than small ovoid or spheroidal fragments of the spleen, which at first sight might be taken for lymphatic glands. I have never seen more than two supernumerary spleens in man. It is said that they are more frequent in the fœtus than in the adult: this opinion is erroneous. ‡ It has been said that ten, twelve, and even twenty-three supernumerary spleens have been observed. Without denying the possibility of the fact, I am inclined to doubt its occurrence. As the spleen is always multiple in a great number of animals, supernumerary spleens in man may be regarded as the last trace of such an arrangement.

With regard to the examples of congenital or accidental absence of the spleen mentioned by some authors, it should be remarked, that they were accompanied with serious diseases of the abdomen, and that small adherent spleens, lost in some measure among the surrounding organs, may easily have escaped notice in a not very close examination.

Size and weight. There is no organ which varies more than the spleen in regard to size and weight. These differences may be referred to the following heads: —

Individual differences. It is in vain to attempt to establish a relation between the size of the spleen and that of the liver, or between the size of the spleen, and the stature, weight, constitution, and habits of the individual. §

* [This reflection is called the *ligamentum phrenico-lienale*. The spleen is also connected by the peritoneum to the arch of the colon.]

† The great end of the stomach is the most fixed part of that viscus, on account of its connection with the œsophagus. Changes of position in this organ affect partly the portion between the pylorus and the cardia, and partly the pylorus itself.

‡ It is true that a greater number of cases of supernumerary spleens in the fœtus have been recorded, than in adults; but the fact is easily explained, if we consider that in the fœtus supernumerary spleens cannot escape notice, whilst they are often difficult to be seen in the adult, on account of the fat with which the omenta are loaded.

§ The spleen is proportionally larger in man than in the lower animals. It has been said, as if

Differences from physiological conditions. The spleen is often found small, wrinkled, shrunk, or as it were withered and collapsed; a state that certainly supposes the opposite condition of distension. In other cases the spleen is large, and looks as if it were stretched. Ought we then to admit with Lieutaud *, that the pressure from the distended state of the stomach during digestion diminishes the size of the spleen, which on the other hand becomes the seat of an afflux of blood in the intervals between the occurrence of that process. This idea is perhaps erroneous as far as regards the periods of collapse and turgescence; but it is correct as to the principal fact, viz. the alternation of those two opposite conditions.

Differences from age. The spleen is proportionally smaller in the fœtus than in the adult, and in the adult than in the aged.

Differences from disease. The morbid differences in the size of the spleen suggest most important considerations. In a great number of patients suffering with intermittent fevers, more especially when this organ is already enlarged from previous attacks, it is manifestly swollen during each access. Hypertrophy of the spleen may proceed to an extraordinary extent; so that this organ, which in the natural condition is withdrawn so deeply into the left hypochondrium as not to be seen on opening the abdomen, in certain cases fills almost the whole of the abdominal cavity; while its weight, which varies from two to eight ounces in the healthy condition, may be as much as ten, twenty, or thirty pounds; one case, indeed, has been recorded, where the spleen weighed forty-three pounds.

Atrophy of the spleen is very rare. I have seen it reduced to the weight of two drachms.

The *specific gravity* of the spleen is, to that of water, as 1160 to 1000.

The spleen, both upon the surface and in the interior, most commonly resembles in colour the dark lees of wine. This colour, however, presents many varieties from a deep brown red to a pale grey. When the surface has been some time exposed to the air, it becomes bright red, like the surface of venous blood soon after its abstraction. Age, the kind of death, and diseases, have much effect on the colour of this organ, the different parts of which are not always of a uniform tint. I have seen a spleen of a deep chesnut brown hue.

Consistence. One character of the tissue of the spleen is its extreme friability. In general it may be lacerated by the pressure of the finger, to which it communicates a feeling of crepitation, and emits a sound, like the crackling produced by bending tin. The spleen may be regarded as the most friable of all organs excepting the brain. Thus examples have been recorded of its laceration from blows, or falls upon the abdomen, and even from a general concussion, or from the contraction of the diaphragm and abdominal muscles during violent exertion, &c.

The consistence of the spleen also varies much in different individuals, and in diseases; indeed, the most important alterations of this organ may be referred to either increased or diminished consistence. In induration, which is generally accompanied with hypertrophy, the tissue of the spleen is compact, brittle, and dry, and breaks like a piece of compact resin. In softening, carried to its highest degree, the spleen is converted into an inorganic pulp, exactly resembling a healthy spleen broken down by the fingers, and containing a greater quantity of fluid than natural. This state is often observed after

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it were possible to establish a relation between two such variable terms as the weight of the spleen and the body, that the former is $\frac{1}{200}$th of the latter.

* Lieutaud asserts that he has constantly found the spleen larger when death has occurred whilst digestion was going on in the stomach, than when it has happened after that process had been completed; but the spleen varies so much in size, that we cannot compare the spleen of one subject with that of another. An ingenious experiment has been made, the result of which is opposed to Lieutaud's opinion: out of four newly born puppies, belonging to the same litter, two were kept without food, whilst to the other two milk was given: on killing them their spleens were all found of the same size.

malignant fevers *, and when the membranes are torn, the substance of the spleen escapes spontaneously.

Figure. The spleen has a crescentic form; its long diameter is vertical, its concavity directed to the right, and its convexity to the left side. It may be compared, as was done by Haller, to a segment of an ellipse cut longitudinally. It presents for consideration an *external* and an *internal surface*, and a *circumference*.

The *external* or *costal surface* is convex, smooth, and in relation with the diaphragm, which separates it from the ninth, tenth, and eleventh ribs †; hence arises the influence of contractions of the diaphragm upon the spleen, and the possibility of its being ruptured during a violent effort. This relation also accounts for the pain felt in the region of the spleen after quick running, and the difficulty and pain attendant on a strong inspiration made whilst running by persons in whom the spleen is hypertrophied.

We frequently find a prolongation of the liver almost completely covering the external surface of the spleen.

The *internal* or *gastric surface* is concave in all directions, and presents, at the junction of the two anterior thirds with the posterior, a somewhat irregular series of openings, which are themselves irregular in form and number, are situated at greater or less intervals, and arranged longitudinally. This row of openings is called the *fissure*, or *hilus* (*h*, *fig.* 154.), *of the spleen*. The *gastro-splenic omentum* is attached near this fissure. Some varieties are observed in the arrangement of the internal surface of the spleen. Thus, it sometimes presents an uniform concavity, and sometimes there is a sort of projecting ridge opposite the hilus, which divides it into two unequal parts, one anterior and larger, the other posterior and smaller: in the latter case, which is common, the spleen is of a prismatic and triangular form.

The following are the relations of the internal surface: — the part situated in front of the hilus has relations with the great cul-de-sac of the stomach, and, on the right and behind this cul-de-sac, with the gastro-splenic omentum and the vasa brevia situated within it: the left extremity of the liver, which, as we have seen occasionally, covers the external surface of the spleen, is more frequently in relation with the internal surface of that organ. Behind the hilus the spleen corresponds with the left kidney, suprarenal capsule, and pillar of the diaphragm, which separate it from the spine, and with the small extremity of the pancreas.

The *circumference* is elliptical; its *posterior border* is thicker above than below, and is in relation with the kidney, which it sometimes covers through its entire length; its *anterior border* is thinner, and is applied to the stomach; its *upper extremity* is thick, often bent upon itself, and in contact with the diaphragm, from which however it is occasionally separated by the liver; its *inferior extremity* is pointed, and rests upon the angle formed by the transverse and descending colon, or upon the portion of transverse mesocolon, which supports that angle. The circumference of the spleen is notched, and sometimes marked more or less deeply by fissures, which are prolonged upon both its surfaces, particularly upon the external surface, and which divide it into a greater or less number of distinct lobules. This lobular arrangement is the last indication of the multiple spleens, of which we have already spoken. The description of the relations just given applies when the stomach is empty; when that viscus is distended, they are somewhat different. The spleen, which before was separated from the stomach by the gastro-splenic omentum, is then applied directly to it, and is moulded upon it, so as it were to cover its walls. It has no longer any relations with the kidney and the vertebral column, but

* Vide Anat. Path. avec. planches, liv. ii., art. MALADIES DE LA RATE. I have been able to collect the splenic fluid in a medicine phial, and to submit it to different experiments.

† It is said that the ribs produce marks upon the spleen from the pressure exercised by them upon it during life. I have never observed this appearance, and can only conceive it to exist in cases of hypertrophy of the spleen.

is situated below and behind the great cul-de-sac of the stomach, and not to the left of it; and it becomes horizontal instead of being vertical, as when the stomach is empty.

Structure. Besides two investing membranes, one serous, the other fibrous *, the spleen consists of cells having fibrous parietes, and filled with a grumous fluid † of the colour of port wine dregs, of certain corpuscules not very distinct in the human subject, of a very large artery and still larger vein, and of lymphatic vessels and nerves.

The *serous* or *peritoneal coat* invests the whole spleen with the exception of the hilus, which corresponds to the gastro-splenic omentum. It gives a smooth appearance to the spleen, lubricates its surface, and, at the same time, fixes it to the neighbouring parts by the bands which it forms. Its internal surface adheres closely to the fibrous membrane.

The *proper coat* of the spleen forms a sort of fibrous shell, which is strong notwithstanding its tenuity and transparency. This membrane is the seat of those cartilaginous plates which are so often found upon its surface, and which conceal its true colour. It is intimately united to the peritoneal membrane by its outer surface, and adheres still more closely by its inner surface to the tissue of the spleen by means of exceedingly numerous and dense fibrous prolongations, which penetrate it in all directions, and interlace in every way, so as to form areolæ or cells, the arrangement of which we shall hereafter examine. Further, the proper coat is not perforated at the hilus for the passage of the vessels; but by an arrangement similar to that already noticed in the liver, it is reflected around the vessels opposite the hilus, like the capsule of Glisson, and is prolonged upon both the arteries and veins, forming sheaths which divide and subdivide like the vessels themselves, and receive the prolongations given off from the inner surface of the proper coat.

This arrangement has been very well described by Delasonne (*Mém. Acad. des Sciences*, 1754), and especially by Dupuytren (*Thèse de M. Assolant*). It follows, therefore, that the basis of the spleen is composed of a fibrous structure, consisting of an investing fibrous membrane, of fibrous sheaths which accompany the vessels in their divisions and subdivisions even to their terminations, and of prolongations arising from the inner surface of the membrane, interlacing in all directions, and attached to the outer surface of the sheaths. ‡

The internal framework of the spleen is, therefore, an areolar tissue, which may be very well displayed by washing away the pulpy matter of this viscus by means of a stream of water; there will then remain a whitish areolar and spongy tissue. This is also very clearly shown by injecting it either with mercury or some coloured liquid, or even by inflating it with air blown through a puncture. The coats are then raised in different places, and after desiccation the areolar structure becomes evident. This experiment also shows that the spleen is divided into a number of compartments, for without rupture only a small portion of the organ can be injected in this way.

It appears then that the proper tissue of the spleen is composed of an areolar fibrous network and of a pultaceous matter, of the colour of port wine lees,— the *splenic juice or matter*, regarded by the ancients as one of the fundamental humours of the body called atra bilis, and which modern chemists have not yet sufficiently examined.

We have now to determine the arrangement of the cells, and the relation between these cells and the arteries, veins, and nerves.

The splenic artery. No organ of so small a size, receives so large an ar-

* See note, *infrà*. † See note, p. 539.

‡ [This basis or framework is more or less developed in the different species of animals: it is much stronger in the horse than in the ox. The proper coat of the spleen, together with the sheaths for the vessels, and the prolongations or trabeculæ given off from it, are highly elastic, and are generally stated to consist of yellow elastic tissue, not of ordinary fibrous tissue.]

tery. The splenic artery is in fact the largest branch of the cœliac axis, and, on this account, ruptures or wounds of the spleen are almost always followed by fatal hæmorrhage. It is also remarkable for its tortuous course; when reduced to half its original size, from having given off several branches, it enters the spleen by four or five branches at greater or less distances from each other. These branches divide in the usual manner in the substance of the organ, and preserve their tortuous character even to their terminations. One peculiarity well worthy of attention is, that the arteries constantly divide in a radiating manner, so that air, or water, or tallow, thrown into one arterial division, does not pass into the branches of the others. This mode of division is observed not only in the larger, but also in the smaller arteries*, so that the spleen may be considered as an aggregate of a considerable number of small spleens, united together by a common investment; and accordingly, if in a living animal one division of the splenic artery be tied, the portion of the spleen to which it is distributed becomes blighted, whilst the rest remains in the natural state. This arrangement of the arteries may be shown in a very striking manner by injecting their several divisions with differently coloured substances. The injected matters will not mix, and the line of demarcation between the lobes will become evident.

This structure explains how multiple spleens may occur in man and the lower animals, and why there are so many varieties in this respect in the animal series.

Some branches from the splenic, lumbar, and spermatic arteries enter the spleen through the folds of the peritoneum.

The *splenic vein* is four or five times larger than the artery: it forms one of the principal roots of the vena portæ, and is almost equal to the other root formed by the superior mesenteric vein. The venous communication between the spleen and the liver has, in a great measure, given rise to the opinion that they are connected in function. The spleen is filled by the numberless and large divisions of this vein; it might even be said that the texture of the spleen is essentially venous, that it is composed of a venous plexus or an erectile tissue, and that it bears the same relation to the veins that the lymphatic glands do to the lymphatic vessels. All the splenic cells communicate with the veins, or rather they are nothing more than these veins themselves supported by the fibrous columns and sheaths already described: this is shown by the following considerations and experiments:—

1. If, according to the example of Delasonne†, we examine the spleen of the ox by laying open the splenic veins and their divisions by means of a grooved director, we shall find that these veins are almost immediately reduced to their lining membrane, and perforated with very distinctly formed foramina, through which the dark reddish brown splenic matter is visible. These foramina soon become so numerous, that the veins are converted into cavities or cells, the walls of which are perforated with openings of various sizes, filled with the splenic pulp. This arrangement, which is most manifest under water, proves that the tissue of the spleen is composed of venous cells‡, like the corpora cavernosa of the penis. In man, the horse, and the dog, the great veins are not perforated with foramina, but the cellular and areolar arrangement of the splenic veins at a certain depth is not less manifest.

2. If we inject the splenic artery, the spleen will become very slightly increased in bulk at first, *i.e.* as long as the injected matter does not pass into the venous system; but as soon as this occurs, and it does so readily, the increase

* [The minute arteries ramify in tufts, or penicilli.]

† Delasonne has described the structure of the spleen in the ox as belonging to the human subject.

‡ [According to Mr. Kiernan, these venous cells are lateral dilatations, which communicate with the venous trunk by small branches. They contain only blood however, for the red pulpy matter of the spleen is said by Müller to be *external* to and not *within* them. This red substance consists principally of red granules, about the size of the blood-globules, but spherical, not flattened.]

in size becomes rapid: it follows, therefore, that the communication between the artery and the splenic cells is indirect.* On the other hand, if we inject the vein, the cells are immediately dilated, and the spleen becomes prodigiously increased in bulk: it is easy to perceive that the communication is direct, and that the venous system in some measure forms the basis of this organ.

We can very seldom meet with a human spleen sufficiently healthy, for the following experiment. It will succeed perfectly with the spleen of a horse, which is of a much denser structure. The spleen ought in the first place to be freed from the liquid which it contains; this must be accomplished by forcing water into the splenic artery. The water will return by the veins, at first turbid, then merely tinged, and at last limpid and pure.† I have in vain attempted to force the injection from the veins into the arteries. After the water, air should be blown into the artery, so as to empty the spleen as much as possible of any liquid which it may contain.

If we examine a spleen thus freed of its contained matter, we observe that it is wrinkled and as it were shrivelled on the surface, and remarkably diminished in bulk; and on making a section of it, we find a white spongy tissue, composed of laminæ or fibres interlacing in every direction.

The following preparation‡ exhibits this structure most fully:—The spleen of a horse, prepared in the way I have indicated above, and weighing one pound, could receive ten pounds of tallow. The injection was thrown in by the veins: at each stroke of the piston, the spleen swelled up readily, an evident proof that the splenic cells communicate directly with the veins; while in order to obtain the same effect by injecting through the arteries, very considerable force was required. The injection of the spleen by the veins did not take place in an uniform manner, but successively; in one injection, the upper part was injected before the lower, and the anterior border before the posterior. The independence of different portions of the spleen on each other exists in regard to their veins as well as their arteries. I have been enabled to observe the resistance offered by the tissue of the spleen to the distending power; a resistance which caused the injection to flow back whenever the impelling force was discontinued. The cells are extensible to a certain degree, beyond which they resist very powerfully: it does not appear that they possess any elasticity.§

After some days when desiccation was complete, the spleen thus injected was divided into several portions, which were then immersed in spirits of turpentine moderately heated. The tallow by which all the cells were distended, and which had taken the place of their contents, having been dissolved out, the sections presented a spongy, areolar structure, like that of erectile tissue, as found in the corpora cavernosa, or the substance of the placenta: and this cannot be considered, as Meckel would have it, as the artificial result of the insufflation and injection, which lacerate, as he believes, a part of the

* It has been erroneously asserted that the communication between the artery and vein is more direct in the spleen than in any other organ. The great anastomoses, visible to the naked eye, between the splenic artery and vein, admitted by Spigelius, Diemerbroeck, Bartholin, and others, is purely imaginary. The precise mode of communication is still unknown.

† This injection, which requires considerable force, continued without interruption for a long time, occasions an exudation of a perfectly transparent fluid upon the surface of the spleen, even when the water returned by the vein is still turbid. Here we have an imitation of an exhalant process. And as this transudation takes place without rupture, it is evident that there are a set of vessels by which it is effected.* Instead of making an injection, which is always troublesome, we may attach the splenic artery to a tube, which is itself adapted to another tube running from the bottom of a cistern; the column of water will overcome the resistance offered to its passage from the arteries into the veins, and in twenty-four hours it will pass through perfectly limpid.

‡ This mode of preparation was suggested to me by the plan adopted with the corpora cavernosa by Bogros, prosector to the Faculty, who died a victim to his zeal for science.

§ [The lining membrane of these venous cells is not very extensible, but the trabeculæ between which they lie are highly extensible and elastic also.]

* [This transudation evidently depends on the porosity or permeability of animal tissues, and not on the existence of any special vessels.]

vessels and fibrous tissue. (*Manuel d'Anatomie*, t. iii. p. 479.) This spongy cellular structure explains why the spleen, as well as the corpora cavernosa, is susceptible of such great variations in bulk; and why it is sometimes found collapsed and wrinkled, and sometimes distended, and as it were swollen. Are the splenic cells lined by the internal membrane of the veins? if so, the membrane is so thin as to be incapable of demonstration.

Corpuscules of the spleen. Malpighi described, as existing in the spleen, certain corpuscules, regarded by him as the principal elements in this organ, and believed by him to effect some important changes in the splenic blood. These corpuscules, which Ruysch considered to be essentially vascular, have been again brought into notice by Delasonne, who demonstrated them by maceration. Haller denied their glandular nature, because, as he said, there can be no glands where there is no secretion and no excretory ducts. The question is not, however, whether these corpuscules are glands or not, but rather whether they exist at all. It is certain that in many animals, in the dog and the cat for example, a great number of granules may be seen scattered through the spleen, and which, according to a calculation, the accuracy of which I do not guarantee, would seem to form two fifths of the weight of the organ. These corpuscules are soft, whitish or reddish, and vary in diameter from a fourth of a line to a line. They do not appear to me to exist in man.*

The *lymphatic vessels* of the spleen are divided into the superficial and deep. The superficial only are well known; a certain number pass from the spleen to the stomach; they all terminate in lymphatic glands situated opposite the hilus, within the layers of the gastro-splenic omentum.

Nerves. The nerves are derived from the solar plexus, and are termed the splenic plexus. It has been stated that some terminal divisions of the pneumogastric have been seen distributed upon the spleen. Several of the nerves are remarkable for their size, which enables us to examine in them the peculiar structure of the ganglionic nerves, and also to trace the splenic nerves themselves deeply into the substance of the organ.† We are completely ignorant of their mode of termination.

As to the *proper ducts* of the spleen, said to pass directly from that organ to the great cul-de-sac of the stomach, or even to the duodenum, and to pour into these parts a peculiar liquid, it may be confidently stated that they are purely imaginary. And again, the three kinds of vascular communication between the spleen and the stomach cannot in any way explain the afflux of liquids from the spleen to the stomach; in fact, the arterial vasa brevia of the stomach are given off from the splenic artery before it reaches the spleen; nor do the venous vasa brevia enter the splenic vein until after it has left the hilus of the spleen; the lymphatic vessels alone pass directly from the spleen to the stomach, but they are superficial, and have no connection with the splenic cells.

There is no cellular tissue, properly so called, in the spleen, which nevertheless is liable to inflammation.

Developement. In opposition to the liver, the spleen is smaller in proportion as it is examined nearer the period of conception. It appears late; it begins to be distinguishable towards the end of the second month, and it then resembles a clot of blood. I have never seen it developed from separate lobules,

* [The corpuscules here described are not those discovered by Malpighi, but large soft greyish bodies, rarely found in the human spleen, and the nature of which is not understood. The Malpighian corpuscules are much smaller; they are very evident in the ox, sheep, and pig; they lie in the red pulpy matter externally to the venous cells, and are attached by short pedicles, or without pedicles, to the minute arteries, which, however, have not otherwise any special relation to them; they contain greyish granules, similar in size and form to those of the red pulpy matter. In the human spleen they are very difficult to distinguish.

The extremities of the divided trabeculæ may be mistaken for white corpuscules.]

† The sensibility of the spleen is very important. In a living animal it may be cut or torn without any apparent signs of pain. Dogs have been seen devouring their own spleens, which had been drawn out of the abdomen! What a difference in this respect between the spleen and the intestine; and yet they derive their nerves from the same source.

which were afterwards to be united by a common investment. At birth, its proportions are almost the same as at subsequent periods. The spleen is hard, and as it were tense, in most infants who die during birth: this is probably owing to impeded circulation.

The changes which the spleen undergoes during growth, both in density and in size, are partly physiological, which are not very remarkable, and partly pathological; these are very considerable, but they are foreign to my subject. In the aged the spleen decreases, like all other organs; and atrophy of this organ, which may proceed so far that it only weighs a few drachms, is often accompanied by the developement of a cartilaginous shell.

Functions. The functions of the spleen appear to me to be referrible to its structure and its vascular connections. The quantity of blood which passes through it, its entirely vascular structure, and the physical qualities of the splenic pulp prove, on the one hand, that the blood sent to the spleen serves other purposes besides that of nutrition; and on the other, that it undergoes some important changes, of which we are completely ignorant, because the means of analysis are wanting; but whatever they may be, they have undoubtedly some connection with the functions of the liver *, for in all animals possessing a spleen, even though its arterial blood does not come to it from the same trunk as the hepatic artery, the veins of the spleen terminate in the venous system of the liver. It is therefore extremely probable, that the spleen performs an important office in the abdominal venous system; but what this office is we do not know; and what tends to confound all our calculations is, that extirpation of this organ in animals does not seem to have any marked effect upon their health, that the most complete atrophy of the spleen is consistent with the most regular performance of all the functions, and that hypertrophy, even to such a degree that the organ occupies almost the whole of the abdomen, merely produces a discolouration of the skin, diminished nutrition, and, in young subjects, an arrest of growth.

The spongy and vascular texture of the spleen, and the absence of valves, which allows the venous blood to regurgitate into the spleen when there is any obstacle to the circulation, has led to the opinion that the spleen is nothing more than a diverticulum intended to restore the equilibrium of the abdominal venous system whenever it is deranged; and this opinion, which we owe to Haller, is pretty generally admitted.† A modification of this opinion is, that the spleen fulfils, with regard to the circulation in general, and especially to the abdominal circulation, the office of the safety-tube of Wolf in chemical apparatus. It is certain that compression of the splenic vein in a living animal causes tumefaction of the spleen, which gives place to a quick collapse, as if by elastic contraction, when the pressure on the vein is removed: it is certain that the whole structure of the spleen indicates that this organ may undergo alterations of expansion and turgescence and of collapse and flaccidity; and it is known, that, during intermittent fever, the spleen may be felt below the false ribs, &c. But all this leads to presumptions, and not to certainty.

From the preceding considerations it would follow, that the spleen is only an accessory organ.

* We cannot state with Malpighi, that the spleen is the preparatory organ of the bile, because we have seen that it is extremely probable that the liver is concerned in the process of sanguification.

† May we not quote in support of this view, the pain felt in the region of the spleen, after violent running, which can only be referred to extreme distension of this organ.

THE ORGANS OF RESPIRATION.

General observations.— The Lungs and Pleura.— The Trachea and Bronchi. — Developement of the lungs.— The Larynx—its structure, developement, and functions.— The Thyroid gland.

After describing the digestive apparatus, the object of which is to elaborate solid and liquid materials for the reparation of the waste that occurs in the body, and at the same time to present a vast surface for the absorption of those materials, we naturally turn to the consideration of the *apparatus of respiration*, the object of which is to renew the vital properties of the blood by the action of atmospheric air in the lungs.

This latter apparatus, which is much less complex than the former, is composed, 1. of the *lungs*, the essential organs of respiration; 2. of the thorax, a cavity forming a sort of bellows, and having walls capable of alternately expanding and contracting; 3. of a tubular apparatus, by which the lungs communicate with the external air, and which consists of the *bronchi*, *trachea*, *larynx*, *pharynx*, and *nasal fossæ*; for it is only accidentally, so to speak, and in order to render respiration more certain, that air is allowed to pass through the mouth.

The thorax has been already described (see Osteology and Myology), and also the pharynx, which is common to both the respiratory and digestive passages.

The nasal fossæ, situated at the entrance of the respiratory passages, form the natural passages for the introduction of the air, and at the same time serve for the reception of the organ of smell, by which sense we may consider the qualities of the air are examined. Their bony framework has been already described under osteology. The pituitary membrane which covers the irregular surfaces of these fossæ will be described in the article devoted to the organs of the senses; we shall only consider, in this place, the lungs, the trachea, and the larynx.

The Lungs.

The *lungs* (*pulmones*; πνεύμων, from πνέω, to breathe; *p p*, *figs.* 155. 170, 171.) are the essential organs of respiration. Whilst the presence of an alimentary canal is the attribute of all animals, that of lungs is limited to those vertebrata which live in the air, different modes of respiration prevailing in the other classes.

Number. The lungs are two in number; but as the air which penetrates them is received from one tube, and the blood circulating through them is derived from one vascular trunk, they must be regarded as separated parts of a single organ; by this arrangement, respiration is rendered certain, and its unity maintained.

Situation. The lungs are *situated* (*p p*, *fig.* 155.) in the thoracic cavity, which is in a great measure occupied by them, and effectually protects them from the action of external agents; they are placed on each side of the heart (*h*, *figs.* 155. 170, 171.), with which physiologically they are so directly connected; they are separated from each other by the mediastinum (*m*); hence the independence of the two cavities in which they are contained. Being separated by the diaphragm from the stomach, the liver, and all the other abdominal organs, they are so inclosed in all directions as not to be liable to displacements, or rather such displacements are only partial, and due to a loss of substance in the walls of the cavity in which they are placed.

Size. The size of the lungs necessarily corresponds exactly with the

capacity of the thorax, and therefore, like it, is subject to variations; and as, on the one hand, the size of the lung is generally a measure of the energy of respiration, and, on the other, the energy of respiration is a measure of the muscular strength, one cannot be astonished that a capacious chest, coinciding with broad shoulders, should be the characteristic of a sanguine temperament and athletic constitution.

In the natural state there is neither air nor watery fluid between the parietes of the thorax and the surface of the lung. The absence of air or other fluid may be shown after death as well as upon a living animal, by raising the intercostal muscle from the costal pleura, so as to preserve the latter *, or by removing the muscular fibres of the diaphragm. It is then seen that the lung is always in contact with the parietes of the chest; in some subjects it even appears as if ready to escape; but scarcely is the thorax opened when the lungs instantaneously collapse, in consequence of the expulsion of the air from their interior. It is very common to find a small quantity of serum in the cavity of the pleura, but it is probable that this fluid did not exist during life. There is no space to be filled up here as in the cranium.

The differences in the size of the lungs depend, 1. on the state of inspiration or expiration. Attempts have been made to determine the difference from this cause by estimating the volume of air inspired or expired; it is about thirty cubic inches, and may be increased to forty in forced inspiration or expiration: 2. on age; thus, in the fœtus, the lungs are relatively much smaller than after birth; 3. on some morbid condition. The lungs diminish in size, when the abdominal viscera encroach upon the thorax, either in ascites, in pregnancy, or in diseases of the liver, which organ has been found in some cases to become enlarged entirely by encroaching on the chest, and to extend as high up as the second rib. They diminish also when the heart is enlarged in aneurism, or when a large quantity of fluid is accumulated in the pericardium. In effusions into the thorax, the fluid takes the place of the lung; the latter gradually wastes, and is reduced to such a thin lamina, or to so small a mass, that it has sometimes been overlooked in a superficial examination; but if in such cases air be blown into the trachea, the organ appears of its full size, and gradually fills the remainder of the cavity. This extreme diminution of the lung without any alteration of its substance, proves that the size of the organ is essentially dependent upon the air within it. Attempts have been made to calculate exactly the quantity of air contained in the cavity of the lungs, or, in other words, the capacity of these organs: according to one estimate, which can only be regarded as an approximation to the truth, it would seem to be about 110 cubic inches after expiration, and 140 inches after an ordinary inspiration.

When an effusion in the thorax has been very slowly absorbed, the lung of the affected side remains atrophied, and the thoracic cavity contracted, whilst the other lung acquires a very considerable size, so that the mediastinum is pushed to one side, and the healthy lung passes beyond the median line.† In certain cases of acute pneumonia, and in rickets affecting the thorax, we often see one of the lungs reduced to very small dimensions, whilst the other is very much enlarged.‡

The size of the two lungs is not absolutely the same. In consequence of the heart projecting into the left cavity of the thorax, the transverse diameter of the left lung is not equal to that of the right; and on account of the projection of the liver into the right cavity, the vertical diameter of the right lung is less than that of the left. After allowing for these facts, the difference is in favour

* In order to demonstrate the absence of air, we may also repeat another experiment performed by Haller, which consists in opening the thorax of a dead body under water.

† In a case of chronic induration of the left lung the deviation of the mediastinum was so great, that the right lung was in relation with the left costal cartilages.

‡ The lungs become less increased in size from inflammation, than most other organs; and this peculiarity is explained by the vesicular structure of the lung, the increase in size being effected at the expense of the cavity of the air-vesicles.

of the right lung. In determining the size of the lungs, we must bear in mind, that the lung as well as the thoracic cavity gains in one direction what it loses in another: elongated lungs, which are regarded as particularly liable to phthisis, have not seemed to me to be smaller than the lungs of a person of similar stature but having a broad chest.

The *weight* of the lungs must be examined with reference to their specific gravity and to their absolute weight. The *specific gravity* of the lungs is less than that of any other organ, and even much less than that of water. Their lightness depends on the great quantity of air which penetrates them in every direction, so that the lungs rise to the surface of the fluid in which they are immersed. The specific gravity of the lungs presents some important differences depending on age. Thus, before birth, and in an infant that has died during birth without having respired, the lungs sink in water; on the contrary, they swim when the infant has breathed; not because any change has taken place in the intrinsic nature of the organ, but because the air has insinuated itself into the cells. The estimation of the specific weight of the lungs constitutes what is called in legal medicine the *hydrostatic test*. In the adult the lung always floats, notwithstanding any efforts which may be made to expel the air contained in the pulmonary cells; it seems as if the air enters in some way into the composition of the lung, and even in vacuo it cannot be completely extracted. The specific gravity of the lungs varies also from *disease*. Thus, lungs infiltrated with serum, or indurated by inflammation, being completely or partially deprived of air, on the presence of which their lightness depends, assume, in a greater or less degree, the appearance of compact organs, such as the liver or the spleen.

The *absolute weight* of the lung varies from similar causes. From *age*: thus, although the specific gravity of the fœtal lung is much greater than that of the adult, yet its absolute weight is considerably less. In infants that have not breathed, the weight of the body is to that of the lungs as 60 to 1 on an average, whilst in those that have breathed, the proportion is as 30 to 1, so that the changes in the lungs resulting from respiration are such as to double their weight. We may easily conceive the great importance of this fact in legal medicine. This method of estimating the weight of the lungs is known by the name of the *static* test.

The absolute weight of the lungs varies much in *disease*. Healthy lungs are very light; diseased lungs may become eight or ten times heavier than natural, without increasing in size. The lungs almost always becoming engorged at their posterior border during the last moments of life, their weight must not be estimated from an ordinary corpse. It must undoubtedly have been from the examination of engorged lungs that authors have stated their average weight to be four pounds.

Colour. The colour of the lungs varies according to age and disease. In the fœtus they are reddish-brown; after birth rosy white; in the adult and in the aged they are greyish-blue, and amost always marked by black spots, forming points, lines, or patches, and describing polygons more or less regular in figure. These black patches, which become much more numerous in advanced age, co-exist with the black deposits in the bronchial glands, and probably depend upon the same cause; they lie below the serous covering of the lungs, and are very superficial, excepting in disease. The posterior part of the lung is usually of a reddish-brown colour, because it is distended with blood and serum. It has not been shown that this is altogether a post mortem condition, and the necessary consequence of the position of the corpse upon its back; many facts would, on the contrary, induce us to admit that it occurs antecedently to death.

Density, crepitation, and cohesion. The lung, a spongy or aerial organ, so to speak, is the least dense of all the organs in the body; it yields to the pressure of the hand, and, if no cause prevents the escape of the air, it loses very much of its original size. I have remarked, when speaking of the spleen, that, *under pressure, that* organ emitted a peculiar noise, or rather gave rise to

a sensation which might be compared to the crackling of tin, and that this sound was the result of rupture of the fibrous prolongations which traverse its tissue. Pressure of the lung causes a sensation and a sound somewhat analogous to the preceding; this sound is called *crepitation*. It may, in fact, be compared to the sound produced by the decrepitation of salt, or the rattling of paper. This crepitation is only observed under a moderate pressure, and if the sensation communicated be strictly noted, we shall find that it is the feeling of a resistance overcome. On careful examination of the portion of lung which has thus crepitated, bubbles of air are found under the pleura; in fact, emphysema is produced. Notwithstanding its slight density, the tissue of the lungs possesses tolerable strength; it resists laceration to a certain point; and all its parts are pretty firmly bound together.

Resistance to distension. The lung, though it yields to the finger without recovering itself at all, or only very imperfectly, is yet possessed of great elasticity, but such an elasticity as is in harmony with its functions. It also offers powerful resistance to any distending force. Thus, if a stopcock be adapted to the trachea of a dead body, and the lungs be inflated by means of bellows having double valves, the pulmonary tissue becomes extremely tense and hard; the effort necessary to rupture some of the air-cells and produce emphysema, is surprising. In opposition to those authors who speak of the dangers of artificial insufflation of the lungs of asphyxiated persons, I have in vain endeavoured with all the force I could employ in expiration, to produce a laceration of some of the pulmonary cells: and how, it may be asked, without great means of opposing every attempt to dilate them beyond measure, could the lungs resist the force to which they are subjected during violent exertions?

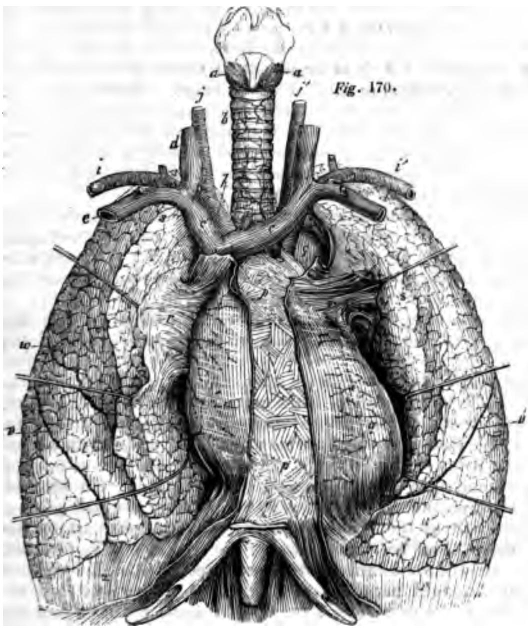
Elasticity. The lungs are very elastic, *i. e.* they have a constant tendency to collapse, and to free themselves of part of the air contained in their cells. It is this elasticity which maintains the vaulted form of the diaphragm after the abdomen has been opened, and occasions the lung to collapse suddenly, when an opening is made in the parietes of the thorax: before the chest is opened, the atmospheric pressure operating through the trachea, prevents the elasticity of the lungs from being brought into action.* This elasticity is also shown by the quick collapse of inflated lungs. I have been accustomed to demonstrate in my lectures, perfectly healthy lungs preserved in alcohol. After having shown how far the inflation of the lungs may be carried, I open the stopcock used in the experiment, and the lungs instantly collapse, driving out the air with considerable force.

Shape and relations. The lungs are shaped like an irregular cone, deeply excavated on the inner side, with the base below and the apex above; they present for consideration an external and an internal surface, an anterior and a posterior border, a base, and an apex.

Outer or costal surface. This surface is irregularly convex, corresponding to the concavity of the thoracic parietes with which it is in contact, and on which it is exactly moulded; it is in relation with the costal pleura, which separates it from the ribs and the intercostal muscles. It presents a deep fissure, the *interlobular* fissure, which penetrates the entire thickness of the lung as far as the root. This fissure commences below the apex of the lung (v', *fig.* 171.), passes downwards and forwards (v', *fig.* 170.) as far as the anterior part of the base, upon which it encroaches a little at its termination. It is simple in the left lung (v'), but is bifurcated in front in the right; the lower division of this bifurcation continues in the original direction; the upper division (w) passes upwards and forwards. The left lung, therefore, is divided into two portions or *lobes*, distinguished as the *superior* (s') and the

* [The lungs do not collapse until the chest is opened, because the atmospheric pressure is exerted *only* on the inner surface of the lungs, their outer surface being protected from it by the unyielding parietes of the thorax. When this protection is removed, the pressure on both surfaces is equal, and the elasticity of the pulmonary tissue is then enabled to act.]

inferior (*u'*); while the right is divided into three *lobes*, the *superior* (*s*), the *inferior* (*u*), and the *middle* (*t*). Of these lobes the inferior, comprising the base of the lung, is larger than the superior, which forms the apex: the middle lobe is the smallest. The contiguous surfaces of these lobes are plane, and covered by the pleura: they are often adherent, and sometimes purulent matter collects between them, and being surrounded on all sides by adhesions, it hollows out, as it were, a cavity for itself, at the expense of the corresponding surfaces of the lobes, and thus simulates an abscess of the lung.



There are many varieties in the arrangement of these lobes. Thus, sometimes the fissures, and more especially those which bound the middle lobe, do not reach as far as the root of the lungs, but are only slightly indicated. Three lobes are not unfrequently found in the left lung, or four in the right; there were four lobes in the lung of a negro lately presented to the anatomical society.

Examples are on record of lungs with five, six, and even seven lobes, but in general this multiplicity of lobes is only rudimentary, and represents the normal condition in the majority of animals. The dog, the sheep, and the ox have seven lobes in their lungs.

Inner or mediastinal surface. This corresponds to the mediastinum (*p p*). On it we observe the *root* (*r*) of the lungs, that is, the part at which they communicate with the trachea, through the bronchi, and receive and emit their bloodvessels. This root occupies a very limited space upon the inner surface, one inch in height, and half an inch in breadth; it is situated at the junction of the posterior with the two anterior thirds of this surface, at an almost equal distance from the apex and the base.

That part of the inner surface of the lung which is behind the root, corresponds to the vertebral column and the posterior mediastinum, in which are found, on the left side, the descending aorta and the upper part of the thoracic duct, and on the right side, the vena azygos, the œsophagus, and the lower part of the thoracic duct.

All that portion of the inner surface which is in front of the root, corresponds with the anterior mediastinum, and is excavated to receive the heart (*l*); and as the heart projects more to the left than to the right side, it follows that the left lung, which corresponds to the left border and apex of the heart, and higher up to the arch of the aorta (*g*), is more deeply excavated than the

right lung, which corresponds to the right auricle (*m*) and the vena cava superior (see *fig.* 170.). We can obtain an accurate idea of the manner in which the lungs are excavated for the reception of the heart, only by examining them when inflated; we are then struck with the propriety of the expression of Avicenna, who called the lung the *bed of the heart.* We can also understand how diseases accompanied with enlargement of the heart may directly influence the respiration, by reducing the size of the lungs. These organs, it may be remarked, are here in apposition with the heart through the medium of the pericardium and the pleura. I should not omit to mention their relation with the phrenic nerve, which is affixed closely to the pericardium by the pleura. In the fœtus the lungs are in relation anteriorly with the thymus gland, which presses them backwards.

The *anterior border* is thin and sinuous, presenting on the left side two notches, one inferior and very large, corresponding to the apex of the heart; the other superior and small, for the subclavian artery. On the right side there are also two notches, but smaller than those on the left; an inferior for the right auricle, and a superior for the vena cava superior.

The *posterior border* (*fig.* 171.) is the thickest part of the lung. It fills the deep costo-vertebral groove situated at each side of the dorsal portion of the spine.

The *base* is concave, and exactly moulded upon the convexity of the diaphragm (*x*, *fig.* 170.); it is therefore a little more excavated on the right, than on the left side. Its circumference is very thin, and slightly sinuous. Like the diaphragm, the base of the lung forms an inclined plane from before backwards and downwards; and it occupies the deep angular groove formed behind, between the diaphragm and the parietes of the thorax. On account of this obliquity of its base, the vertical diameter of the lung is much greater behind than in front; and as the posterior border is the largest part of the organ, it may be conceived that an examination of the lung should be directed chiefly to this part. It is of importance to form a correct idea of the manner in which the base of the right lung and the convexity of the liver are arranged with regard to each other. The liver is, as it were, received into the concavity of the base of the lung so completely, that the posterior part of this base is almost on a level with the lower surface of the liver. The relation of the liver with the base of the lung, which is only separated from it by the diaphragm, explains how abscesses and cysts of the liver may burst into the lung.

The *apex* is obtuse, and projects above the first rib, a very strongly marked impression of which is found on its anterior surface. I have observed that the height of the portion which passes above the first rib varies in different subjects. In several I found it from an inch to an inch and a half. In an aged female, in whom the base of the thorax was extremely constricted, the apex of the lung (*i. e.* the part bounded below by the depression corresponding to the first rib) was two inches in height. May not the mechanical pressure of the inner edge of the first rib upon the apex of the lung exercise some influence in the very frequent developement of tubercles in that region? In order to form a correct idea of the apex of the lung, that organ must be previously inflated.

The whole surface of the lung is free, smooth, and moistened with serum; it is connected with the rest of the body only by its root, which attaches it to the bronchi and the heart, and by a fold of the pleura. It is very rare to meet with lungs free from adhesions upon their surface, so that the older anatomists regarded these adhesions, whether filamentous or otherwise, as natural formations.

Structure of the Lungs.

On examining the structure of the lungs, we find in each an investing membrane or serous sac, formed by the pleura, and a proper tissue. We shall commence with the pleura.

The Pleura.

Dissection. In order to obtain a view of the costal pleura, saw through the six or seven upper ribs behind, near their angles; cut through the cartilages of the same ribs, at a distance of some lines from their sternal articulations; remove the intermediate portions of ribs and intercostal muscles with great care, so as to leave the costal pleura untouched. The cavity of the pleura may be inflated.

In order to see the mediastinal and pulmonary portions, the costal pleura must be opened, and its continuity traced.

The *pleura* (πλευρὰ, the side) is a serous membrane, and therefore a shut sac, which is extended partly over the parietes of the thorax, and partly over the lungs. There are two pleuræ, one for the right and the other for the left lung. The following is their general arrangement: —

The pleura lines the parietes of the thorax, the ribs, and the diaphragm, forming the *pleura costalis* (*p p*, *fig.* 161.), and *pleura diaphragmatica;* it invests the entire surface of the lung, constituting a sort of integument for it, and forming the *pleura pulmonalis:* lastly, it is applied to the pleura of the opposite side, so as to form a septum between the two lungs; this part is the *mediastinal pleura.*

In order to facilitate the description of the pleura, we shall suppose it to commence at a certain point; and then following its course without interruption, shall trace it back to the point from which we started. If we thus commence at the sternum, we shall find that it lines the internal surface of the thorax, being applied to the ribs and the intercostal muscles, and covering the mammary vessels and lymphatic glands in front, the intercostal vessels and nerves behind, and the ganglia of the great sympathetic opposite the heads of the ribs: below, it is reflected upon the diaphragm, and covers the whole of its upper surface: above, it is reflected beneath the first rib, and terminates in a cul-de-sac, intended for the reception of the apex of the lung, and projecting more or less above that rib.

Having reached the sides of the vertebral column, the two pleuræ are reflected forwards as far as the root of the corresponding lung, and form, by their approximation, a septum, which is called the *posterior mediastinum.* This septum contains within it the aorta, the œsophagus, the pneumogastric nerves, the thoracic duct, the vena azygos, a considerable quantity of cellular tissue, a great number of lymphatic glands, and the trachea. We see then that the two pleuræ are by no means in immediate contact.

Arrested, as it were, by the root of the lungs, the pleura is reflected outwards behind that pedicle, passes over a small portion of the pericardium, covers all that part of the inner surface of the lungs which is behind its root, and also its posterior border and its outer surface, dips into the interlobular fissure, so as completely to invest the contiguous surfaces of the lobes, is reflected over their anterior margin upon their inner surface, reaches the root of the lung, and covers its anterior surface, is then reflected forwards upon the side of the pericardium, in front of which it is applied to the pleura of the opposite side, and at length arrives at the border of the sternum, from which we had supposed it to commence.*

The antero-posterior septum formed by the two pleuræ, between the ster-

* [A fold of the pleura reaching from the lower edge of the root of the lung downwards to the diaphragm, is called *the ligamentum latum pulmonis.* It is triangular; its base is attached to the diaphragm, one side to the lung, and the other to the mediastinum.]

num and the root of the lung, is called the *anterior mediastinum* (*m*, *fig.* 155.).* This septum is not vertical nor median, like the posterior mediastinum, but is directed downwards and to the left side, an arrangement that is connected with the oblique position of the heart, which encroaches more upon the left than the right cavity of the thorax. It follows from this that the upper part of the anterior mediastinum (*p p*, *fig.* 170.) is behind the sternum, whilst its lower portion is behind the left costal cartilages, and hence the interior of this mediastinum may be reached, without opening the cavity of the pleura, by introducing an instrument close to the left border of the sternum, opposite the fifth rib. The anterior mediastinum is narrow in the middle, and expanded above and below, like an hour-glass. The upper cone or expansion is very much developed in the fœtus, and is occupied by the thymus gland, which is afterwards replaced by cellular tissue: the lower cone or expansion is much larger, and contains the heart and pericardium, the phrenic nerves, and in front of the heart a large quantity of cellular tissue.

This latter, which is so abundant in the anterior mediastinum, communicates freely above with the cellular tissue in front of the neck, and below with that of the abdominal parietes, through a triangular interval existing in the diaphragm behind the sternum.

This double communication explains how the pus of an abscess formed in the neck or in the mediastinum may reach the surface in the epigastric region.

The pleura has two surfaces, one an external, the other internal.

External or adherent surface. This does not adhere with equal firmness to all the *parts* which it covers. The *pleura costalis* is but slightly adherent, and may be separated from the ribs and the intercostal muscles with the greatest ease. It is sometimes raised in the situation of these muscles by subjacent adipose tissue. It is strengthened by a layer of fibrous tissue, which, notwithstanding its tenuity, performs an important part in diseases of the chest; it explains why abscesses formed in the parietes of the thorax so seldom open into the cavity of the pleura, and why effusions into the pleura are so rarely discharged externally. The *diaphragmatic pleura* is more adherent than the costal. We sometimes find here, especially round the pericardium, some large fatty appendages, resembling the appendices epiploicæ of the great intestine. The pleura is extremely thin upon the lungs (*pleura pulmonalis*), where it is not strengthened by any fibrous tissue; and although it is more adherent here than the parietal pleura, still it can be easily demonstrated. The *mediastinal pleura* is united to the parts contained within the mediastinum by very loose cellular tissue, but it adheres more firmly to the sides of the pericardium, to which the phrenic nerves are closely applied.

The *internal* or *free surface* is smooth †, moistened with serum, and in contact with itself throughout its entire extent, as is the case in all serous membranes. The adhesions so commonly met with here are altogether accidental. The structure of the pleura is cellular. ‡ It is doutbful whether it receives any arteries and veins. The vascular network, which is sometimes so highly developed after pleurisy, does not belong to it, but is situated upon its external surface. No nerves have been traced into this membrane.

Uses. Each pleura forms an investment for the corresponding lung, separates it from the parietes of the thorax and from the other viscera, and at the same time facilitates its movements upon the walls of the thoracic cavity by means of the serosity, which is constantly exhaled and absorbed at its internal surface.

* According to Meckel, the anterior mediastinum is the portion of the septum situated in front of the heart, just as the posterior mediastinum is the part situated behind that organ.

† [It is covered with a squamous epithelium, and cilia have been observed upon it in some of the mammalia.]

‡ [Beneath the pleura another cellular layer may be demonstrated: and in the lung of the seal and leopard an elastic coat is said to exist.]

The proper Tissue of the Lungs.

The pulmonary tissue appears like a spongy or vesicular texture, the cells of which are filled with air. This is rendered apparent by the most simple inspection of the surface of an inflated lung, either with the naked eye, or with a lens. A microscopical examination of sections of a dried lung shows the existence of this cellular or vesicular texture in the most evident manner throughout the entire organ. The different shapes of the cells and their unequal size may also be distinguished.

But what are the relations of the cells with each other? Do they communicate throughout the whole extent of the lung, or only within a determinate space, or are they independent of each other? In order to resolve these questions, it is necessary to examine the lung of a large animal, of the ox for example, the structure of which is similar to that of the human lung, on which the same observations may be subsequently repeated. We then observe that the surface of the lung is traversed by lines, dividing it into lozenge-shaped compartments; and if the lung be previously inflated, it will be seen that the surface is slightly depressed opposite these lines, but that it bulges out between them. If, by means of a delicate tube, air be blown under the pleura, or if the lung be forcibly inflated through the trachea, so as to rupture some of the vesicles and produce emphysema, we then perceive that the lines bounding the lozenge-shaped intervals correspond to thin layers of very delicate but tolerably loose cellular tissue, which divide the lung into a large number of groups or cells, which may be completely separated from each other by dissection, until at last we arrive at the pedicles by which they are united into a common mass.

These groups of cells are the *lobules of the lung;* the cellular tissue uniting them is the *interlobular cellular tissue*, which is extremely delicate, never loaded with fat, but often infiltrated with serosity, and is subject to emphysema. A great number of lymphatic vessels traverse this cellular tissue: they are often visible to the naked eye, and are always easily injected; they pass deeply into the substance of the lung.

The pulmonary lobules do not communicate with each other, but each is perfectly independent of the rest. This fact is shown by inflation; it is most distinctly proved by dissection; and an examination of the lungs of the fœtus will remove all doubts concerning it. The pleura and the interlobular cellular tissue having but little strength in the fœtus, the lobules become separated without dissection, resemble grapes attached to their foot-stalks, and hang from a common stem, formed by the divisions of the bronchi and the pulmonary vessels.

This independence of the lobules is also proved by pathological anatomy: thus we continually find one lobule infiltrated with serum, with pus, or with tubercular matter, in the midst of perfectly healthy lobules.

Each lobule then is a small lung, and may act independently of those by which it is surrounded. I have satisfied myself by a great number of experiments, that the lobules are not all equally permeable to the air, and that a moderate inflation of the lungs, made as much as possible within the limits of an ordinary inspiration, does not perhaps dilate one third of the pulmonary lobules. I have observed, and this fact appears to me of great importance, that the most permeable lobules are those of the apex of the lung; and this perhaps will explain the greater frequency of tubercles in that situation.* There are some lobules in the lung which are kept as it were in reserve, and only act in forced inspirations. †

* It is rather too much to say that pneumonia almost always attacks the base of the lungs; this disease has no special locality; it perhaps as often affects the apex as the base.

† In ordinary respiration, perhaps not more than one third of the lung is in action; exercise and yawning are probably required, from the necessity for bringing the whole lung into action. Thus a great number of tubercles may exist in the lung, without manifesting their presence by impeding ordinary respiration. *It is in violent inspiration, in exercise, in efforts of the voice, and in all movements during which the* whole of the lungs is called into play, that we detect *the existence of a lesion in the central* organ of respiration.

The pulmonary lobules vary much in shape; all the superficial ones resemble a pyramid, the base of which is at the surface of the lung; the deep lobules lie along the bronchial tubes, have *numerous* facettes, and are exactly fitted to each other, like the fragments of mosaic work; but they are so irregular in form, that it would be equally difficult and useless to give a description of them.

The lung then is a collection of an immense number of lobules, placed along the bronchial tubes and pulmonary vessels, which serve as a support and framework for them, and to which they are appended by pedicles; they are united to each other by serous cellular tissue, and are all covered by one great cell, formed by the pleura, which merely unites together this great number of parts.

The problem of the texture of the lungs reduces itself therefore to the determination of the structure of a single lobule; but the difficulty is rather postponed than got rid of, for each lobule is a little lung, receiving an air-tube and an artery, and giving out several veins and lymphatics.

Before describing the arrangement of the air-tube, and the vessels in each lobule, we shall say a few words upon the structure of the lobule itself.

Each lobule is an agglomeration of cells and of vesicles, all of which communicate with each other. * These cells are always full of air. Their size is not always the same; M. Magendie has already shown that the pulmonary cells are smaller in the infant than in the adult, and smaller in the adult than in the aged.† Nor is the size of the different cells in the same lobule constantly uniform. All the cells of the same lobule communicate, but they are not all equally permeable. * Thus, in a given degree of inspiration, some cells only are distended, while others require a greater degree of dilatation. The septa between the cells of a lobule are incomplete *, and consist of filaments or lamellæ; and the reticulated arrangement of the cells, which is so evident to the naked eye in the lung of the frog, seems to me to represent with tolerable accuracy the appearance of the human lung under the simple microscope.

With regard to the structure of the cells *, we cannot admit the existence of muscular fibres round them; the anatomist is unable to demonstrate them, and physiology rejects them. The most probable opinion is, that they are formed of dense cellular tissue, or of an elastic fibrous tissue, and that the bloodvessels are ramified upon their parietes.

The Air-tubes.

The air-tubes of the lungs consist of the *trachea*, the *bronchi*, and their *divisions*.

The Trachea.

The *trachea* (from τραχὺς, rough), or *aspera arteria* (*b*, *figs.* 170, 171.), is the common trunk of the air-tubes of the lungs; it is situated between the larynx (*a*, *fig.* 171.), of which it is a continuation, and the bronchi (*p p'*), which are nothing more than its bifurcation in front of the vertebral column, extending from the fifth cervical to the third dorsal vertebra. ‡ In this situation, however, it is moveable, and may easily be pushed to the right or left side. This mobility has occasioned serious accidents in tracheotomy, and has led to the invention of an instrument for fixing the trachea. § Its direction is vertical; it occupies the median line above, but appears to be slightly deflected to the right side below. I have often seen it somewhat flexuous, but these slight deviations

* See note, p. 556.

† Diseases have a remarkable influence upon their size; in chronic catarrh, and in some varieties of asthma, we find the pulmonary cells excessively dilated. Laennec has called this dilatation pulmonary emphysema.

‡ The term trachea is derived from the roughness produced by the projection of the cartilages of the windpipe. The application of the term arteria, by the ancients, to the vessels which carry red blood, arose from a serious anatomical mistake. These vessels being habitually empty in the dead body, it was supposed that they contained air during life; and hence the name artery, which they still retain.

§ By a surgeon of the name of Buchot. The mobility of the trachea is an obstacle to its puncture in the operation of tracheotomy

only existed when the neck was bent upon the thorax, they disappeared during extension.

Dimensions. The length of the trachea equals that of the space between the fifth cervical and the third dorsal vertebræ, and is therefore from four to five inches ; but it varies according as the larynx is raised or depressed, and as the neck is flexed or extended. The difference produced in its length, by the utmost elongation and shortening, may be about half its entire length, *i. e.* from two inches to two inches and a half; its shortening is limited by the contact of its cartilaginous rings. *

The *diameter* of the trachea is determined by that of the cricoid cartilage of the larynx; it is much wider in the male than in the female, and after than before puberty. Individuals who have been many years labouring under chronic catarrh have the air passages remarkably large, especially the trachea. The mean diameter of the trachea is from ten to twelve lines in the male, and from nine to ten in the female. The trachea is not of equal diameter throughout; it is almost always dilated at its lower extremity where it bifurcates. In some subjects it gradually increases in size from above downwards, and resembles a sort of truncated cone, with the base below.

External surface, form and relations. In front and on the sides the trachea is cylindrical (*fig.* 170.), but is flattened behind (*fig.* 171.), so that it resembles a cylinder, the posterior fourth or third of which has been removed. The external surface is rough, and as it were interrupted by circular ridges, which correspond to the cartilaginous rings. The relations of its external surface must be examined in the neck and in the thorax.

Relations of the cervical portion (*x, fig.* 140.). In *front* the trachea is in relation with the thyroid body, the isthmus of which being sometimes very narrow and sometimes very largely developed, covers a greater or less number of the rings of the trachea. In general, the first ring of the trachea is above the isthmus of the thyroid. Below the thyroid body the trachea is in relation with the sterno-thyroid muscles, the edges of which are separated only by the linea alba of the neck ; also with the cervical fascia, the thyroid plexus of veins, a considerable quantity of cellular tissue, the thyroid artery of Neubauer, when it exists, and the brachio-cephalic artery, which always passes a little above the supra-sternal notch. All these relations are of the greatest importance in reference to the operation of tracheotomy. *On the sides* the trachea is embraced by the lateral portions of the thyroid body, and therefore, in diseases of that organ, the corresponding part of the trachea is deformed, flattened on the sides, and elliptical or even triangular. The compression of this canal may be carried so far as to produce suffocation. The common carotid artery and the pneumogastric nerve are in contact with it on either side; and hence the possibility of wounding that artery in the operation of tracheotomy. A great number of lymphatic glands are situated upon the sides of the trachea, and may become so large as to prevent the passage of the air. Lastly, all the relations of the trachea, excepting those with the thyroid body, take place through the medium of a very loose cellular tissue in which this canal is embedded.

Behind, the trachea is flat and membranous, and is in relation with the œsophagus, which projects a little beyond it on the left side, and separates it from the vertebral column. The left recurrent nerve is situated in the groove formed between the trachea and the œsophagus in this direction; the right recurrent nerve lies behind the trachea.

The immediate relation of the trachea with the œsophagus explains why

* The elongation and shortening of the trachea is much more limited in man than in birds, in which the rings of the trachea are moved by longitudinal muscles, and can be drawn within each other; in the greatest possible degree of shortening three rings overlap each other, so as to equal only one in height; and therefore the trachea of a bird may be diminished by two thirds. These peculiarities of structure are connected with the different uses of the parts; the trachea in man and other mammalia merely conveying the air (*un porte-vent*), while the trachea of birds conveys the voice (*un porte-voix*).

foreign bodies arrested in the gullet may produce suffocation, and require the performance of tracheotomy.

The softness and flexibility of the trachea opposite the œsophagus have appeared to some physiologists to be intended merely to facilitate the dilatation of the latter during the passing of the food; but we shall see that the air-tubes continue to be membranous behind, even where they have no relation with the œsophagus, and comparative anatomy, which shows the trachea to be cylindrical in the bird, and angular behind in the ox, the sheep, &c. most completely refutes this opinion.

Relations of the thoracic portion of the trachea. In the thorax, the trachea occupies the posterior mediastinum. It corresponds in *front*, proceeding from above downwards, with the sternum and the sterno-thyroid muscles; with the left brachio-cephalic vein (*c*, *fig.* 170.); with the brachio-cephalic artery (*h*), an aneurism of which may open into the trachea: its left side is as it were embraced between the brachio-cephalic artery (*h*), and the left common carotid (*j*); with the back part of the arch of the aorta (*g*), which rests immediately upon it, and hence the dyspnœa which so generally accompanies aneurism of the aorta, and the frequency of its bursting into the windpipe; and lastly, lower down, with the bifurcation of the pulmonary artery, which corresponds with that of the trachea.

The trachea is in relation *behind* with the œsophagus, which separates it from the spinal column; and *on the sides* with those portions of the pleuræ which form the mediastinum, with the pneumogastric nerves, and with the upper part of the recurrent nerves.

In all its thoracic portion the trachea is surrounded by numerous lymphatic vessels and glands, and by a loose and very abundant cellular tissue, which communicates with that of the cervical region. These lymphatic vessels and glands with the loose cellular tissue are the parts immediately adjoining the trachea; and it may readily be conceived that enlargement of the glands may be productive of serious consequences.

Internal surface. The internal surface of the trachea is of a rosy colour, and presents the same circular ridges as the external surface, but they are more distinct. It is also remarkable in its membranous portion for the projection of certain vertical fasciculi, to which we shall again refer when speaking of the structure of these parts.

The Bronchi.

The *bronchi* (βρόγχος, *guttur*, *p*, *p*, *fig.* 171.) are the two branches formed by the bifurcation of the trachea, which spread out from each other at a right or a slightly obtuse angle; one (*p*) is intended for the right, the other for the left (*p′*) lung. A tolerably strong triangular ligament exists at the angle of the bifurcation, and seems intended to prevent too great separation of the bronchi.

The bronchi differ *from* each other in many respects; first, in *width*. The right bronchus is much wider than the left, and its diameter is not much less than that of the trachea. In a female, whose trachea was ten lines in diameter, the right bronchus was eight, and the left five. This difference in width corresponds with the difference in the size of the two lungs, and may afford a tolerably correct measure of that size: they differ also in *length*, the right bronchus being one inch in length, the left two: also in *direction*, the right bronchus passing less obliquely than the left, probably because it enters the corresponding lung sooner than the latter; and lastly, in their *relations*. Thus, the right bronchus is embraced by the vena azygos, which forms a loop immediately above it, in order to terminate in the vena cava superior. The left bronchus is embraced above by the arch of the aorta (*g*), and has an important relation with the œsophagus behind, which it crosses obliquely. Both are connected with the pulmonary plexus of nerves; both

are surrounded with lymphatic glands, remarkable for their black colour, and for being frequently diseased, and which in some measure fill up the angle formed by the bifurcation of the trachea; and lastly, both have the following relations with the pulmonary artery and veins. Each pulmonary artery ($k\,k'$) is situated in front of the corresponding bronchus, then passes above, and finally behind it. The two pulmonary veins on each side ($l\,l$, $m\,m$) are situated upon the same vertical plane as the corresponding artery; they pass upwards in front of the artery and the bronchus, which is, therefore, behind the blood vessels.*

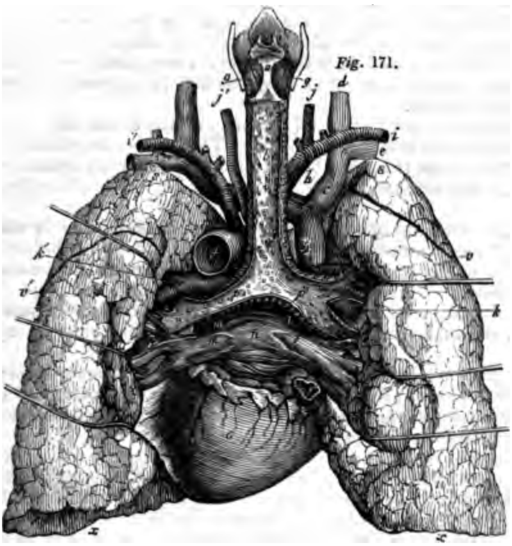


Fig. 171.

The *shape* of the bronchi exactly resembles that of the trachea, *i. e.* they represent cylinders, the posterior fourth of which has been removed, and which are formed by parallel rings. The area of the two bronchi is greater than that of the trachea, in the same way as the area of the bronchial ramifications is greater than that of the bronchi themselves, so that the velocity of the expired air increases as it approaches the exterior.

At the root of the lungs the bronchi divide into two equal branches, but in a somewhat different manner. The upper branch of the bifurcation of the right bronchus is the smaller, and is intended for the upper lobe of the lung, in order to reach which it is bent slightly upwards. The lower branch, which is larger, follows the original direction, and, after passing about an inch, divides into two unequal branches, a small one for the middle lobe, and a larger one for the lower lobe. I have once seen a small bronchus proceeding from the lower part of the trachea directly to the apex of the right lung; the vena azygos passed between it and the regular bronchus.†

The secondary divisions are precisely the same in the two lungs; each branch of a bifurcation becomes bifurcated in its turn. All these ramifications pursue a diverging course, some ascending, others descending, and after proceeding for a variable distance, they again bifurcate; so that by separating a small portion of the pulmonary substance, we can see that several diverging series of tubes proceed in succession from a bronchial trunk, and pass outwards into the tissue of the lung. The prevailing mode of division of the air-tubes in the lungs is that called *dichotomous*, viz. a division into two equal branches, which we shall afterwards find to be the most favourable to the rapid trans-

* [In consequence of the oblique direction of the left bronchus towards the root of the lung, the corresponding pulmonary artery is placed somewhat above it, and the pulmonary veins below it; on the right side, the pulmonary artery is in the middle, the bronchus above, and the veins below.]

† This appears to be the natural arrangement in the sheep and the ox.

mission of the contents of any vessel. (See ARTERIES.) The two branches of a bifurcation separate at an acute angle, and a spur-shaped process, situated within the tube at the angle of division, cuts and divides the column of air. However, some small bronchial tubes are not unfrequently found arising directly from a principal division, to be distributed to the nearest pulmonary lobules. The number of subdivisions, which always corresponds with that of the pulmonary veins, is not so great as might at first be supposed; there are not many more than fifteen.

The form of the bronchial ramifications (*bronchia*) differs essentially from that of the *bronchi* themselves and of the trachea. They represent, indeed, a complete cylinder, which is not truncated behind; and the cartilages, instead of forming rings, have another arrangement, which I shall point out when speaking of their structure.

Relations. The first divisions of the bronchi are surrounded even in the substance of the lung by very numerous and dark coloured bronchial lymphatic glands, enlargement of which is a very frequent result of chronic bronchitis, and may cause suffocation.

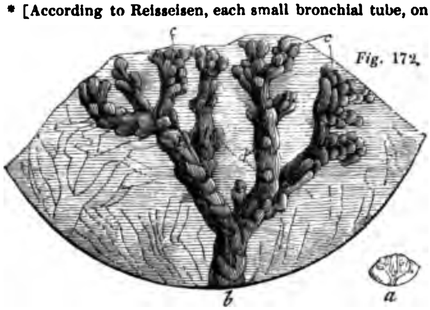
The bronchial ramifications, as I have said, support the pulmonary lobules which are applied to and moulded upon them, and are united to them by very loose cellular tissue.

The following are their relations with the branches of the pulmonary artery and veins: — the artery always accompanies the bronchial ramification, and is situated behind it; the vein is often separated from it; the artery and vein are not unfrequently found interlaced around the corresponding bronchial tube.

Relations of the bronchial ramifications with the pulmonary lobules. Each pulmonary lobule has its bronchial tube. This tube is cylindrical, of uniform diameter throughout, and entirely membranous; having entered the lobule, it dilates into a small ampulla, and disappears. There can be little doubt that these small ampullæ have deceived Malpighi, Reisseisen, and others, who have stated that the bronchial tubes terminate in culs-de-sac; so that, according to these authors, each pulmonary cell is the termination of a particular bronchial tube. But it is evident that such cannot be the case, for, on the one hand, the bronchial tubes are not sufficiently numerous, and on the other it can be shown that only a single bronchial tube enters into each group of cells or each lobule. If we inject with tallow a lung, which has previously been deprived of air, either by an effusion in the chest during life, or by an artificial one after death, it will be seen that the injection is divided into small globules or rounded tubercles, which correspond to so many pulmonary cells, and that these globules are all connected with a common pedicle, corresponding to the bronchial tube.

Reisseisen who has made this injection, thinks that the granular appearance of the injected matter represents the culs-de-sac, into which it had penetrated.*

* [According to Reisseisen, each small bronchial tube, on entering its corresponding lobule, divides and subdivides in a certain uniform order into numerous twigs (*t*, *fig.* 172.), which, extending towards the surface of the lobule, gradually decrease in diameter, but increase in number, and at length terminate in clusters of short free closed and rounded extremities (*c c*); these are the pulmonary cells, which vary from $\frac{1}{70}$th to $\frac{1}{200}$th of an inch in diameter. Not only are the several lobules independent of each other, but the cells of each lobule have no communication with one another except indirectly through the twig or twigs from which they proceed.



Minute structure of the lung.

This view of the minute structure of the lung, which is opposed

Structure of the Trachea, Bronchi, and Bronchial Ramifications.

Structure of the trachea. The trachea is composed of a series of imperfect cartilaginous rings, separated by an equal number of fibrous rings, and hence it has a knotted appearance; these cartilages keep the canal permanently open. Had the trachea been entirely membranous, it would have collapsed during inspiration, which tends to produce a vacuum in the thorax, and this collapse would have prevented the entrance of the air. The number of the cartilaginous rings varies from fifteen to twenty. They are more prominent on the internal than on the external surface of the trachea. In some subjects they form two thirds, in others three fourths or four fifths of a circle. Each ring has two surfaces, one anterior and convex, the other posterior and concave; an upper and a lower edge, both of which are thin and give attachment to the fibrous rings; and two extremities, which terminate abruptly without being inflected or thickened. In general there is but little regularity in the arrangement of these rings; they are not exactly parallel, nor are they of equal depth, which varies from a line to a line and a half, two, or even two lines and a half; and the same ring is often of unequal depth at different points. Two rings are often united for a certain extent, and sometimes a ring is found bifurcated; indeed, it is probable that differences in the number of the rings depend upon their thus uniting or dividing. They are sufficiently thin to allow of being compressed, so that the opposite surfaces may touch without breaking. Their elasticity enables them to recover their original position immediately, and thus permit free access to the air. They can only be broken when ossified, which is frequently the case in the aged.

The first ring and the two lower rings present some peculiarities. The first is broader than any of the others, especially in the middle line, and it is often continuous with the cricoid cartilage.*

The last ring of the trachea, which forms the transition between it and the bronchi, has the following characters: — the middle part is prolonged considerably downwards, and curved backwards, forming a very acute angle, and is developed into a spur-shaped projection within the trachea, which separates the two bronchi. The two half rings resulting from this arrangement constitute the two first rings of the bronchi. The last ring but one of the trachea presents an angular inflection in the middle, less marked, however, than that observed in the lowest ring.

The fibrous tissue of the trachea. This is arranged in the following manner:— a fibrous cylinder commences at the lower edge of the cricoid cartilage; the cartilaginous rings are situated within the substance of this cylinder in such a manner, that the thicker layer of fibrous tissue lies on their exterior, so that at first sight their internal surfaces would appear to be in immediate contact with the mucous membrane. In the posterior part of the trachea, where the cartilaginous rings are wanting, the fibrous tissue alone forms its basis or framework.

The muscular fibres of the trachea. If we carefully remove the fibrous tissue from the back of the trachea, opposite its membranous portion, we arrive at

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to the opinion of M. Cruveilhier, receives support from what is known concerning the developement of the lungs, and from the analogy between these organs and the compound glands.

In *fig.* 172., after Reisseisen, *a* shows the natural size of the portion represented magnified about nine diameters in *b*. The bronchial twigs and pulmonary cells are seen distended with air; the knots or projections (*d*) on the sides of some of the twigs, indicate the commencement of other twigs into which no air has passed.]

* I have met with one case in which the thin upper rings of the trachea and the cricoid cartilage were joined together, but only on one side; the crico-thyroid muscle and the inferior constrictor of the pharynx evidently arose from the first ring of the trachea. This continuity of the cricoid cartilage with the trachea, manifestly proves that the rings of the latter are cartilages, and not fibro-cartilages.

certain transverse muscular fibres, extending from one end of each ring to the other, and also occupying the intervals between the rings. The existence of these muscular fibres, which I have seen forming a layer half a line thick in certain cases of chronic catarrh, cannot be doubted. It is evident that their contraction must draw the ends of the rings towards each other, and therefore narrow the trachea, the diminution in the width of which is limited by the contact of the ends of the rings.

The longitudinal yellow fasciculi. In the membranous portion of the trachea, between the muscular and the mucous layer, are situated a great number of parallel, longitudinal, yellow fasciculi, which at first sight resemble longitudinal folds, but are not at all effaced by distension; these fasciculi adhere to and produce an elevation of the mucous membrane, and opposite the bifurcation of the trachea they also divide, and are continued into the bronchi.

The nature of this tissue is not well known; it can only belong to the muscular or to the yellow elastic tissue, though I would rather incline to the latter opinion. According to either supposition, its use is to prevent too great an elongation of the trachea and the bronchi; actively in the one case, and by virtue of its elasticity in the other. Not unfrequently some longitudinal fasciculi are found behind the cartilaginous rings.

The tracheal glands. If we carefully examine the posterior surface of the trachea, we find a certain number of ovoid flattened glands (see *fig.* 171.), placed upon the outer surface of the fibrous membrane; and by removing this membrane we see a tolerably thick but not continuous layer of similar glands between the fibrous and the muscular coats; and moreover, if either the inner or the outer layer of the fibrous tissue, situated between the cartilaginous rings, be removed, a series of much smaller glands will be found between these layers, occupying the intervals between the rings, and even extending behind them.

The mucous membrane. This is a continuation of the mucous membrane of the larynx; it is remarkable for its tenuity, which permits the colour of the subjacent parts to be seen through it, and for its intimate adhesion to the structures covered by it. The longitudinal folds of which some authors speak, do not exist; the yellow longitudinal fasciculi have been mistaken for them. Lastly, it presents a great number of openings, from which mucus can be expressed. These openings are nothing more than the orifices of the excretory ducts of the tracheal glands.*

The vessels and nerves. The *arteries* of the trachea are derived from the superior and inferior thyroid. The *veins* are generally arranged thus: some venous trunks running along the inner surface of the trachea beneath the mucous membrane, receive on each side, in the same manner as the vena azygos, small veins corresponding to the intervals between the cartilaginous rings, and then terminate in the neighbouring veins. The *lymphatic vessels* are very numerous; they enter the surrounding glands, which are of considerable size. The *nerves* are derived from the pneumogastrics.

Structure of the Bronchi.

The structure of the bronchi is exactly the same as that of the trachea. The left bronchus has ten or twelve cartilaginous rings; the right has five or six. They both possess transverse muscular fibres, longitudinal yellow fasciculi, glands, &c. Their *arteries* generally arise directly from the aorta, and

* *Structure of the trachea.* [The *muscular* fibres of the trachea are of the involuntary class (see p. 426.), and are attached to the internal surface of the ends of the rings: the *longitudinal* fibres exist all round the trachea, but are collected into bundles on its membranous portion only; they are believed to consist of elastic tissue.

The *glands* of the trachea and bronchi are compound; its mucous membrane is covered with a columnar epithelium, and is provided with cilia, which urge the secretions upwards towards the larynx.]

are named *bronchial.* The *veins* of the right bronchus enter the vena azygos; those of the left terminate in the superior intercostal.

Structure of the bronchial ramifications (*bronchia*). The *fibrous* cylinder of the trachea and the bronchi is prolonged into the bronchial ramifications. The *cartilaginous* rings are remarkably modified beyond the first division of the bronchi; they become divided into segments, which together form a complete ring, so that there is no longer any membranous portion, properly so called, and the bronchial tubes become perfectly cylindrical. The segments above mentioned are oblong, curved, terminated by very elongated angles, and so arranged that they can overlap and be mutually received between each other. They are also united together by fibrous tissue. This arrangement of curved and angular segments exists as far as the last bifurcations of the bronchial tubes; but the size of the segments gradually diminishes, so that they soon form only narrow lines, and ultimately mere cartilaginous points. The fibrous and membranous constituents of the cylinder preponderate more and more over the cartilaginous laminæ, which disappear beyond the ultimate bifurcations of the bronchial tubes, being found last at the several angles of bifurcation: the ultimate bronchial ramifications are altogether membranous.

The *mucous* membrane is prolonged to the very last ramifications, where it becomes extremely thin. The longitudinal *elastic* fasciculi, which were limited to the membranous portion of the bronchi, are expanded over the entire surface of the bronchial tubes beyond their first subdivision. The *muscular* fibres, which are confined to the membranous portion in the trachea and bronchi, become circular on the inner side of the bronchial ramifications, and form an uninterrupted but very thin layer, precisely resembling the circular fibres of the intestinal canal.* When we consider, on the one hand, the arrangement of the cartilaginous segments, which appear as it were shaped expressly for the purpose of fitting between each other at their extremities, and of constituting an apparatus capable of being moved, and on the other the existence of circular contractile fibres on the inner surface of these segments, we cannot doubt that they are moved upon each other, the extent of such motion being measured by the space they have to traverse in order to come into contact. When this is effected, the canals must be almost completely obliterated.†

The Pulmonary Vessels and Nerves.

Besides the trachea, the bronchi and the bronchial ramifications, which may be regarded as forming the framework of the lungs, these organs receive two sets of arteries, viz. the *pulmonary* and the *bronchial;* and give out two sets of veins, also called *pulmonary* and *bronchial.* A very great number of *lymphatics* arise from their interior, and from their surfaces, and they are penetrated by important *nerves.*

The size of the *pulmonary artery* is equal to, if not greater than, that of the aorta; the *bronchial arteries* appear to be distributed upon the bronchi and their ramifications, which they exactly follow.

The *pulmonary veins* correspond with the pulmonary artery: they are two in number for each lung. The *bronchial veins* correspond with the bronchial arteries, and terminate in the vena azygos on the right side, and in the superior intercostal vein on the left.

* *Structure of the bronchi and their branches.* [According to Reisseisen, the *fibrous* cylinder gradually degenerates in the smallest bronchial tubes into cellular tissue; according to the same author, the *longitudinal* elastic and the *circular* fibres can be traced as far as the tubes can be opened. The contractility of the pulmonary tissue on the application of galvanism, recently observed by Dr. C. J. B. Williams, establishes the muscularity of the circular fibres of the bronchial tubes. The *mucous membrane,* as in the trachea, has a columnar and ciliated epithelium; it of course enters into and lines the pulmonary cells.]

† These anatomical facts explain, in a remarkable manner, all the phenomena of nervous asthma, nervous suffocation, &c.

Within the lung, as well as at its root, the pulmonary arteries and veins always accompany the bronchial tubes. The three vessels may be distinguished from each other upon sections of the organ by the following characters: — the *artery* remains open, or rather so, and is of a white colour; the *bronchus* is also open, but of a more or less rosy colour, and contains a frothy mucus, which may be pressed out of it; the *vein* is collapsed, and much more difficult to be seen than the artery. The relations of these three kinds of vessels have not appeared to me to be constant. Notwithstanding the investigations of Haller, the arrangement of the bronchial with regard to the pulmonary arteries and veins is not well known.*

I ought to notice the easy communication between the arteries and the pulmonary veins and bronchial ramifications. The coarsest injection pushed with moderate force passes with the greatest facility from the arteries into the pulmonary veins and the bronchial tubes †; only inflamed portions of the lung have appeared to me to be impermeable.

The *lymphatic vessels*, both superficial and deep, are very numerous; they terminate in the bronchial and tracheal glands, the number and size of which sufficiently declare their importance. The black colour of these glands only begins to appear from the tenth to the twentieth year.

The *nerves* of the lungs are principally derived from the pneumogastrics, but they receive some branches from the ganglionic system. They form a large plexus behind the bronchi, with the divisions of which they penetrate into the substance of the lung. I should observe that there is only one great pulmonary plexus common to the two lungs; and on this circumstance, the sympathy between the two is without doubt partially dependent.

Developement. According to Meckel, the lungs are among the latest organs to appear in the fœtus; they can only be distinctly recognised amidst the other contents of the thorax, towards the end of the second month of intrauterine existence.‡

The lung is smallest at the earliest period of its developement. Its place appears then to be occupied by the thymus, which is the only organ that is seen when the thorax is opened, the lungs being situated behind it, upon each side of the vertebral column. The developement of the lung takes place in an inverse ratio to that of the thymus; the lung increasing in proportion as

* [The following are the results of Reisseisen's observations on this subject. The branches of the *pulmonary artery* accompany the bronchial tubes, and do not anastomose until their termination in a dense network of capillaries upon the walls of the air cells: these capillaries have very thin coats; they are about one twentieth the diameter of a pulmonary cell, and the meshes which they form are scarcely so wide as the vessels themselves. From this network arise the branches of the *pulmonary veins*, which unite into larger and larger trunks, so as to correspond with the divisions of the pulmonary artery; these veins have no valves, and their caliber is not greater, perhaps less, than that of the artery.

Such is the chief mode of distribution of the pulmonary artery and veins; but both vessels, as indicated below, also communicate with the bronchial arteries.

The *bronchial* arteries are the nutrient vessels of the lung; some of their branches are distributed upon the air tubes and to their lining membrane, even as far as the air cells, upon all the pulmonary vessels and nerves, and to the bronchial lymphatic glands; whilst others, passing between the lobules, or upon the surface of the lung, anastomose with twigs from the pulmonary artery, and form, with the branches of the pulmonary vein, a vascular network in those situations, but more particularly beneath the pleura. The branches distributed to the larger bronchia and vessels, and to the lymphatic glands, and also some of the vessels composing the superficial network, terminate in the *bronchial veins*, which, however, cannot be traced very deeply into the substance of the lung. But by far the *greater number* of the bronchial arteries end in the pulmonary veins; for example, those distributed deeply to the smaller air tubes and pulmonary vessels, and to the air cells, and nearly all the vessels which enter into the formation of the interlobular and superficial network.]

† [This is due to *rupture* of the pulmonary vessels, which have exceedingly delicate coats, and are perhaps less supported by surrounding tissue than the vessels of other organs.]

‡ [The developement of the lungs has been traced by various recent observers in frogs, birds, and mammalia, including man; according to Rathke and Müller, it closely resembles, in its early stages, that of the compound glands. In mammalia, the lungs appear at first as a protuberance upon the anterior part of the œsophagus, consisting of a soft mass, like the primitive blastema of a gland: within this substance a more opaque portion is formed, from which white lines extend, dividing and subdividing, and terminating in enlarged extremities; these are accompanied by bloodvessels, and are at first solid, but soon become hollowed out, into the trachea, bronchi, bronchial tubes, and air cells.]

the thymus diminishes. In the last two months of pregnancy the lung is completely developed, and fit for performing respiration.

The weight of the lung in the fœtus and in the adult presents some differences, which are well worthy of attention. During the whole period of intra-uterine life, the fœtal lung is specifically heavier than water; but as soon as the infant respires, it becomes much lighter, and floats in water.

Yet the absolute weight of the lung is sensibly increased; because it receives a much greater quantity of blood than it did previously. Before birth, the absolute weight of the lung to that of the whole body is as 1 to 60; after birth, it is as 1 to 30. It follows, therefore, that lungs which float in water, and which have acquired a much greater absolute weight than they would have had in the fœtus, must belong to an infant that has respired.

After birth the lung participates in the developement of the rest of the body. At the time of puberty it acquires the proportions which it subsequently presents. I have not observed that the lungs are smaller and lighter in the aged than in the adult.

The *colour* of the lungs varies considerably at different periods. In the earlier periods of developement, the lung of the fœtus is of a delicate pink colour; subsequently it becomes of a deep red, like lees of wine, and remains so until the time of birth. After birth, it again becomes of a pink colour. Still later, from the tenth to the twentieth year, black spots become visible at different points along the lines which form the lozenge-shaped intervals on its surface. These spots subsequently unite into lines or patches, which give to the greyish surface of the organ a mottled appearance. The developement of the black matter is so clearly the effect of age, that it is very rare not to find small masses of it in the apex or some other part of the lungs in the old subject. It is worthy of notice, that the black matter appears simultaneously on the surface of the lung, and in the lymphatic glands situated at its root, and along the bronchi.

With regard to *structure*, it may be observed, that during the four or five earlier months of gestation, the pulmonary lobules are perfectly distinct from each other; they may be separated by very gentle traction, on account of the weakness of the pleura and cellular tissue which unites them, as compared with the pulmonary tissue itself. The cartilaginous rings begin to be visible after the third month.

Functions. The lungs are the essential organs of respiration; that process by means of which the blood, though dark and unfit for supporting life before entering these organs, becomes red and vivifying. For the accomplishment of this function, the lungs receive, on the one hand, the atmospheric air, and on the other, the venous blood, the whole of which, in the human subject, passes through the lungs. The air is not drawn in by any power resident in the pulmonary tissue itself, but by the muscular action of the parietes of the thorax; the blood is propelled into it by the right ventricle of the heart. While the blood undergoes the changes above mentioned, the atmospheric air loses a portion of its oxygen, which is replaced by carbonic acid gas. The manner in which these changes in the blood are effected is not yet well known.

THE LARYNX.*

It is necessary to have several specimens, from subjects of different ages and sexes, so as to be able to examine the general relations of the larynx in its

* The voice belongs essentially to the functions of relation, and therefore Bichat describes its organ after the apparatus of locomotion; but the anatomical connections between the larynx and the respiratory organs are such that all animals provided with lungs have a larynx also, whilst the larynx disappears where the lungs cease to exist.

natural situation; its cartilages separated from each other, its ligaments and muscles, its vessels and nerves, and its mucous membrane.

The *larynx* is a sort of box (*pixis cava*) or cartilaginous passage, consisting of several moveable pieces, which form a complex apparatus intended for the organ of the voice. It is *situated* (*v*, *fig.* 140.) in the median line, in the course of the air passages, opening into the pharynx (3) above, and being continuous with the trachea (*x*) below: it occupies the anterior and upper part of the neck, below the os hyoides, the movements of which it follows, and in front of the vertebral column, being separated from it by the pharynx: it is covered by the muscles of the sub-hyoid region which intervene between it and the skin; and it is therefore very liable to wounds, and may easily be reached by the surgeon. Its mobility allows of its being raised, depressed, and carried forwards or backwards; all of which movements are concerned both in deglutition and in the production of different tones of the voice. It may also be carried to the right or left side; but these lateral displacements are most commonly produced by external violence, or by the growth of tumours.

Dimensions. The larynx appears like an expansion of the trachea, and has therefore been denominated its head, *caput asperæ arteriæ.* The exact determination of its dimensions, according to age and sex, or in different individuals, and their relations to the various qualities of the voice, would be extremely interesting in a physiological point of view. Its greater size in the male than in the female, and the developement it undergoes in both sexes, but especially in the male, at the period of puberty, are among the most remarkable phenomena in the human economy.

Form. It is cylindrical below, like the trachea, but is expanded above, and becomes prismatic and triangular. It may therefore be compared to a three-sided pyramid, the truncated apex of which is directed downwards, and the base upwards; it is perfectly symmetrical.

As the larynx is a very complicated organ, I shall describe in succession the numerous parts which enter into its composition. Being intended to admit of the continual passage of the air in the act of respiration, it must therefore present a constantly pervious cavity, having strong and elastic walls; but as it is also the organ of the voice, it requires to be provided with a moveable apparatus, subject to the will. We accordingly find in it a cartilaginous skeleton or framework, much stronger than that of the trachea; certain articulations and ligaments, and a vocal apparatus composed of four fibrous bands, or vocal cords; muscles, which move the different pieces of the cartilaginous skeleton, and produce certain changes in the vocal apparatus indispensable for the production of sounds; a mucous membrane, lining its inner surface; glands, which pour out their fluid upon that surface; and, lastly, certain vessels and nerves.

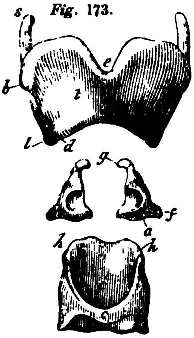
We cannot enter upon a general description of the organ, until we have studied separately its constituent parts.

The cartilages of the larynx. These are five in number; of which three are median, single, and symmetrical, viz. the *cricoid*, the *thyroid*, and the *epiglottis*, and two are lateral, viz. the *arytenoid*, of which the *cornicula laryngis* are merely appendages. The cartilaginous nodules, described by some authors under the name of the *cuneiform cartilages*, and situated in the membranous fold extending from the arytenoid cartilages to the epiglottis, do not exist in the human subject.

The cricoid cartilage. The cricoid or annular cartilage (*c c'*, *figs.* 173. to 177.) forms the base of the larynx; it is much thicker and stronger than any of the others. Its form is that of a ring, whence its name (κρίκος, a ring); it is narrow in front (*c*, *fig.* 173.), where it resembles a ring of the trachea; it is three or four times broader or deeper behind (*c'* and *c*, *fig.* 175.), where it forms by itself alone the greater part of the larynx, being there about an inch in height. *In front*, its *external surface* is subcutaneous in the median line; on each side, it gives attachment to the crico-thyroid muscle, and presents a smooth process (*m*,

fig. 177.) for articulating with the thyroid cartilage. *Behind*, where it is covered by the mucous membrane of the pharynx, it presents in the median line a vertical projection, which gives attachment to some of the longitudinal fibres of the œsophagus, and on each side, a depression for the posterior crico-arytenoid muscle.

Fig. 173.



Its *internal surface* is covered by the laryngeal mucous membrane.

Its *lower border* is perfectly circular, and slightly waved, and is connected by a membrane with the first ring of the trachea; sometimes it is even united with it, and can only be distinguished by its greater thickness.

Its *upper border* is not exactly circular, but is oblong from before backwards, as if the ring had been flattened laterally. It is cut very obliquely forwards and downwards, or rather it is deeply notched *in front*, where it is concave, and gives attachment to the crico-thyroid membrane in the median line, and laterally by its inner lip to a fibrous membrane, which is continuous with the inferior vocal cord, and in the rest of its thickness with the lateral crico-arytenoid muscle.

Behind, and on each side, is an oblong articular facette, the *arytenoid facettes* (*h h*, *fig.* 173.), which are directed outwards and upwards, and articulate with the arytenoid cartilages. Between these two facettes, the upper border of the cricoid is horizontal, and very slightly notched, and gives attachment to the arytenoid muscle. The upper border of the cricoid cartilage is, therefore, horizontal behind, oblique at the sides, and horizontal and slightly concave in front. The arytenoid facettes are situated upon the oblique portion.

The thyroid cartilage. The *thyroid* or *scutiform* cartilage (*t*, *figs.* 173 to 177.), so named because it has been compared to a shield (θυρεός, a shield)*, occupies the upper and fore part of the larynx. It is formed by two quadrilateral plates (or *alæ*), united at an acute angle in the median line, and embracing the cricoid cartilage behind. Its *anterior* or *cutaneous surface* presents in *the median line* an angular projection (below *e*, *fig.* 173.), more marked and deeply notched above, and completely effaced below; much less distinct in the female, in whom it forms only a rounded surface, than in the male, in whom it has received the special appellation of the *pomum Adami.* This angular projection does not appear until puberty; it presents certain individual varieties, but these do not appear to me to have any relation with the qualities of the voice.

On *each side*, the surface (*t*, *figs.* 173, 174.) is smooth and quadrilateral, and has two tubercles behind; one of which is superior (*b*), and the other inferior (*d*). The latter, or larger, is prolonged upon the inferior border of the cartilage. The two tubercles are united by an aponeurotic arch, but there is no oblique intermediate line, as has been generally affirmed. These tubercles, and the imaginary line between them, separate the anterior three fourths of the surface, which are covered by the thyro-hyoid muscle, from the posterior fourth, which is covered by the inferior constrictor of the pharynx and the sterno-thyroid muscle. The tubercles give attachment to these three muscles.

The *posterior surface* (*fig.* 175.) presents, *in the median line*, a retreating angle, which gives attachment to the thyro-arytenoid ligaments, or vocal cords, and to the thyro-arytenoid muscles. This angle is sometimes so acute, that the cartilage has the appearance of having been subjected to strong lateral pressure.

On *each side* (*t t*), the posterior surface projects beyond the cricoid cartilage, and forms part of the lateral groove of the larynx. It is lined by the pharyn-

* The name may also have been derived from its use.

geal mucous membrane, and corresponds in part to the thyro- and crico-arytenoid muscles.

Its *upper border* is horizontal and sinuous, and gives attachment to the hyo-thyroid membrane in its whole extent. It presents a notch (*e*, *fig.* 173.) in the median line; which is shallower, but broader and more rounded, in the female than in the male. On the sides there is a small prominence, which forms a continuation of the superior tubercle, and is often wanting. More posteriorly we find on each side a slight notch, bounded by certain processes, called the *great* or *superior cornua* (*s*, *fig.* 173, 174.) of the thyroid cartilage.

The *lower border* is sinuous, and shorter than the upper, and hence the pyramidal shape of the larynx. It presents a slight median projection, to which the crico-thyroid ligament is attached; in the rest of its extent, it gives insertion to the crico-thyroid muscle, and presents a rough eminence, which forms a continuation of the inferior tubercle; and more posteriorly, on each side, a slight notch, bounded by the *lesser* or *inferior cornua* (*l*, *fig.* 173. 175.) of the thyroid cartilage.

Its *posterior borders* (*s r*, *fig.* 174.) are slightly sinuous, give attachment to the stylo-pharyngei and palato-pharyngei, and rest upon the vertebral column. As the thyroid cartilage projects behind the upper portion of the larynx, it may be regarded as protecting the larynx by its posterior borders resting upon the vertebral column.

The *cornua of the thyroid cartilage* are four in number, *two superior* and *two inferior*, and appear to be prolongations of the posterior borders of the cartilage. They are all rounded, and are bent inwards and backwards; the upper or *great cornua* (*s*) are generally the larger, and are united by ligaments to the os hyoides; the lower or *lesser cornua* (*l*) are usually smaller, and articulate with the cricoid cartilage.

The arytenoid cartilages. The arytenoid cartilages (*a*, *figs.* 173. 175 to 177.) are two in number*, are situated at the upper and back part of the larynx, and have a pyramidal and triangular form; they are directed vertically, and bent backwards like the lip of an ewer, whence their name (ἀρυταίνα, a funnel). Their *posterior surface* (*fig.* 175.) is triangular, broad, and concave, and receives the arytenoid muscle; their *internal surface* is lined by the mucous membrane of the larynx; their *anterior surface* (*fig.* 173.) is convex, narrow, rough, and furrowed, and corresponds to the series of glands called the arytenoid glands, and to the superior vocal cord; their *base* is very deeply notched, articulates with the cricoid cartilage, and is terminated by two processes; one posterior and external (*f*), which gives attachment to the lateral and posterior crico-arytenoid muscles; the other is anterior (*a*), pyramidal, and more or less elongated, has the inferior vocal cord attached to its point, and it forms a fourth, or almost a third, of the antero-posterior diameter of the glottis; their *apex* is surmounted, or rather formed, by two very small and delicate cartilaginous nodules (*g*), which are bent inwards and backwards, and incurvated, so that they almost touch — they are called the *cornicula*. They were very correctly described by Santorini, under the name of the sixth and seventh cartilages of the larynx. They are now generally known as the *tubercles of Santorini*, the *capitula* or *cornicula laryngis*. They appear to me constantly to exist, sometimes closely united with the arytenoid cartilages, and not moving at all upon them, and sometimes perfectly distinct and very moveable.

The epiglottis. The epiglottis (ἐπὶ, upon, and γλωττὶς, the glottis; *i*, *figs.* 174 to 178.), or lingula, forming a moveable and highly elastic valve, is a fibro-cartilaginous lamina, situated (*i*, *fig.* 140.) behind the base of the tongue, and in front of the superior opening of the larynx, not upon the glottis, as its name would seem to indicate.

* It was for a long time believed that there existed only one arytenoid cartilage, because the larynx was always examined when covered by its membranes; so that the word arytenoid, in the works of Galen, is always applied to the two united. Galen only admitted three cartilages in the larynx, — the thyroid, the cricoid, and the arytenoid.

Its *direction* is vertical, excepting at the moment of deglutition, when it becomes horizontal, so as to protect the opening of the larynx like a lid (*laryngis operculum*). Its triangular *shape* has been well compared to that of a leaf of purslaine. It must be separated from the neighbouring parts to be properly studied.

It varies much *in size* in different subjects, but always appears to me to bear some relation to the dimensions of the upper orifice of the larynx, beyond which it almost always projects when depressed.

Its *anterior* or *lingual surface* presents a free and an adherent portion. The *free portion* surmounts the base of the tongue; it may be felt by the finger, and even seen by strongly depressing the tongue.* Three folds of mucous membrane, one in the middle and one on each side, pass from the epiglottis to the base of the tongue.

The *adherent portion* corresponds in front with the base of the tongue, the os hyoides, and the thyroid cartilage. In order to expose it, it is necessary to have recourse to dissection. We then find a *median glosso-epiglottid ligament*, which is very strong, and composed of yellow elastic tissue, and which, I believe, assists in drawing back the depressed epiglottis: its place is occupied by muscular fibres in the larger animals; also a *hyo-epiglottid ligament*, extending from the epiglottis to the posterior surface of the os hyoides; and lastly, beneath this ligament, a yellow fatty tissue, improperly called the *epiglottid gland*, occupying the interval between the epiglottis and the concavity of the thyroid cartilage.

Moreover, the anterior surface of the epiglottis, examined in the vertical direction, is concave above, convex in the middle, and again concave below; it is convex in the transverse direction. The *posterior* or *laryngeal surface* (*figs.* 175. 178.), the curvatures of which are the reverse of those on the anterior surface, is free in the whole of its extent, and covered by the laryngeal mucous membrane.

Circumference. Its upper margin, or the base of the triangle which it represents, is free, bent forwards, slightly notched, and continuous, by two rounded angles, with its lateral margins, from each of which proceed two folds, viz. the *aryteno-epiglottid* (*b*, *fig.* 178.), extending from the epiglottis to the arytenoid cartilage, and inclosing a ligament (*b*, *fig.* 176.), and the *pharyngeo-epiglottid*, situated anterior to the preceding, passing almost transversely outwards, and lost upon the sides of the pharynx.

The epiglottis terminates below in a sort of pedicle, which is extremely slender, and is fixed (*fig.* 176.) into the retreating angle of the thyroid cartilage, immediately above the attachment of the vocal cords. This attachment is effected by means of a ligament, called the *thyro-epiglottid.*

The epiglottis is remarkable for the great number of perforations found in it, which give it an appearance very much resembling that of the leaves of several of the *lauraceæ*. In these foramina we find small glands, which for the most part open on the laryngeal surface of the epiglottis. The so-called epiglottid gland has no relation with these orifices.

It is also remarkable for its flexibility and elasticity; on account of which it is classed by Bichat among the *fibro-cartilages*, a sort of tissue which we have stated does not exist. Its yellow colour gives it an appearance like the yellow elastic tissue. It is brittle, and may be crushed between the fingers; this depends partly upon the nature of its tissue, and partly upon the numerous foramina with which it is perforated, and which necessarily diminish its strength.

The Articulations and Ligaments of the Larynx.

The articulations of the larynx may be divided into the extrinsic and the intrinsic.

* I attach great importance to inspection of the epiglottis in diseases of the larynx.

The extrinsic articulations. The *thyro-hyoid articulation* consists of three ligaments, which unite the thyroid cartilage to the os hyoides. The *middle thyro-hyoid ligament* (*n*, *fig.* 174.) is a loose yellowish membrane, extending from the upper border of the thyroid cartilage (*t*) to the os hyoides (*u*). Its vertical dimensions are much greater at the sides than in the middle; and therefore the cornua of the os hyoides can be raised higher than its body, and hence the sides of the tongue can be elevated so as to form a groove, along which the food glides. This membrane is thick in the middle, and thin and as it were cellular on each side.

Fig. 174.

Relations. It is subcutaneous in the middle, but is covered on each side by the thyro-hyoid muscle. It corresponds behind with the epiglottis, from which it is separated by some adipose tissue, and with the mucous membrane covering the posterior surface of the tongue. It is attached to the posterior lip of the upper edge of the os hyoides, not to the lower edge, as is frequently asserted. It therefore passes behind the os hyoides.

The *lateral thyro-hyoid ligaments* (*o*) may be considered as the margins of the thyro-hyoid membrane. They are small cords, extending from the great cornua of the thyroid cartilage to the tubercular extremities of the great cornua of the os hyoides. We often find a cartilaginous or bony nodule in these ligaments.

There is a very distinct *synovial capsule* between the posterior surface of the body of the os hyoides and the upper part of the thyroid cartilage. Its presence attests the frequent movements which take place between these parts, and during which the middle and upper part of the cartilage is placed behind the os hyoides.

The tracheo-cricoid articulation. The first ring of the trachea is connected with the lower border of the cricoid cartilage by a fibrous membrane of the same nature as that between the rings of the trachea. A small vertical fibrous cord is added to it in the median line in front. This membrane permits some movements between the cricoid cartilage and the first ring of the trachea, and in these the sides of the ring are buried behind the cricoid cartilage.

The *intrinsic articulations* are the *crico-thyroid* and the *crico-arytenoid.* I need merely remind the reader of the articulation between the arytenoid cartilages and the cornicula laryngis.

The crico-thyroid articulations. These are *arthrodial.* Each of the lesser cornua of the thyroid cartilage terminate in a plane surface, directed downwards and inwards, which rests upon a similar plane surface (*m*, *fig.* 177.) on the cricoid cartilage, directed upwards and outwards. An orbicular or capsular ligament (*r*, *figs.* 174, 175.), composed of shining, fasciculated, and parallel fibres, surrounds the articulation, which is provided with a synovial membrane. The posterior fasciculus is remarkable for its length and shape, and extends nearly to the crico-arytenoid articulation. In some subjects the orbicular ligament is very loose, in others the articulation is exceedingly close.

The *movements* are limited to simple gliding, combined with a forward and backward movement of the thyroid cartilage. The direction of the facettes upon the cricoid cartilage renders them fitted to support the thyroid.

The crico-thyroid membrane, or middle crico-thyroid ligament. Besides the preceding articulations, the lower border of the thyroid cartilage is connected with the upper border of the cricoid by a thick triangular membrane, the *pyramidal* or *conoid ligament* (*v*, *fig.* 174.); which is attached in the median line to the lower border of the thyroid cartilage, and the base of which is fixed to the upper border of the cricoid cartilage. This membrane is fibrous, thick, very strong, perforated with foramina for vessels, and is yellow and elastic.

The lateral crico-thyroid ligament. This ligament (*d*, *fig.* 176.) can be well

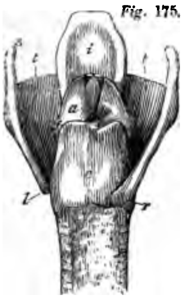
seen only from the inner surface of the larynx. It consists of very strong fibres, which arise from the inner lip of the upper border of the cricoid cartilage, in front of the crico-arytenoid articulation, and pass horizontally inwards to the retreating angle of the thyroid cartilage, below the insertion of the inferior vocal cord (*r*). This ligament, which is very strong, appears to be continuous above with the inferior vocal cord. It is covered on the inside by the mucous membrane of the larynx, and it corresponds on the outside (*d*, *fig.* 177.) to the thyro- (*e*) and crico-arytenoid (*f*) muscles, which separate it from the thyroid cartilage.

The crico-arytenoid articulations. These articulations are effected by mutual reception.

The *articular surface*, upon the cricoid cartilage, is an elliptical facette (*h*, *fig.* 173.), directed obliquely downwards and forwards, and oblong and slightly concave in the same direction. The base of the arytenoid cartilage presents an oblong articular facette, deeply concave from without inwards, *i.e.* in an opposite direction to the former, which it accurately receives.

Means of union. Properly speaking, there is only one ligament, the *internal and posterior* (*e*, *fig.* 175.). It arises from the cricoid cartilage, and is inserted in a radiated manner into the inner and back part of the base of the arytenoid cartilage, and to the inner side of its anterior process, behind the inferior vocal cord. This ligament is very strong, but yet sufficiently loose to allow of certain extensive movements. There is also a very loose *synovial capsule*, which can be easily demonstrated.

Fig. 175.



The *movements* of this articulation, like those of all similar joints, take place in every direction; but the movements inwards and outwards are much more extensive than those which are performed forwards and backwards. On account of the mode of insertion of its muscles, the arytenoid cartilage is not moved in a direct line, but undergoes a partial rotatory movement, the centre of which is in the articulation. In the movement, which is oblique, on account of the obliquity of the articular surfaces, the apex of the arytenoid cartilage is carried either outwards and backwards or inwards and forwards. These motions should be studied with the greater care, because they afford an explanation of the changes which take place in the glottis during the production of the voice.

The aryteno-epiglottid ligament. This ligament (*b*, *figs.* 176, 177.) is constituted by some radiated ligamentous fibres contained within the aryteno-epiglottid fold of mucous membrane, and which pass from the anterior surface of the arytenoid cartilage to the corresponding margin of the epiglottis. In some animals, this ligament is replaced by muscular fibres.

The thyro-arytenoid ligaments, or chordæ vocales. Although there is no immediate relation between the thyroid and the arytenoid cartilages, they are united by four very important ligaments, named the *chordæ vocales*, which require a special description.

The *chordæ vocales* are also called the *vocal bands*, the *ligaments of Ferrein*, or the *thyro-arytenoid* ligaments, because they have a ligamentous appearance, and extend from the retreating angle of the thyroid cartilage to the arytenoid cartilages.

There are two vocal cords on each side, a *superior* (*s*, *figs.* 176. 178.) and an *inferior* (*r*); the space between them is called the *ventricle* of the larynx (*v*), and the interval between the cords of the right and left sides is called the *glottis* (*o*, *fig.* 178.) *. I shall speak of these parts again presently.

* [In consequence of the voice being essentially produced opposite the *inferior* cords, they are termed the *true* vocal cords; the superior being called the *false* vocal cords.]

The *inferior vocal cord* (*r*, *fig.* 176.) is much stronger than the superior, and has the form of a rounded fibrous cord, stretched horizontally from the retreating angle of the thyroid cartilage to the anterior process of the arytenoid cartilage. It is free in all directions, excepting on the outside, where it is in contact with the thyro-arytenoid muscle. Its free portion is covered by the mucous membrane of the larynx, which adheres intimately to it, and is so thin that the white colour of the cord can be seen through it. This vocal cord is thinner than it appears at first sight, the projection which it forms being in a great measure due to the thyro-arytenoid muscle. Its structure is entirely ligamentous, and consists of parallel fibres, running from before backwards, and not at all elastic.*

Fig. 176.

It is continuous below with the lateral thyro-cricoid ligament (*d*).

The *superior vocal cord* (*s*) is smaller, and situated farther from the axis of the larynx than the inferior one (see *fig.* 178.), and extends from the middle of the retreating angle of the thyroid cartilage to the middle of the anterior surface of the arytenoid cartilage: like the inferior cord, it has a fasciculated and fibrous appearance; but the fasciculi are few in number, and are intermixed with a series of glandular masses. The superior vocal cord can only be distinguished from the rest of the parietes of the larynx, from the reflection of the mucous membrane below it, so as to form the ventricle. It is continuous with the aryteno-epiglottid ligament (*b*, *fig.* 176.) above, without any line of demarcation.

Muscles of the Larynx.

These are divided into the *extrinsic* and the *intrinsic*: the former, which move the entire larynx, have been already described, viz. the sterno-hyoid, omo-hyoid, sterno-thyroid, and thyro-hyoid; to which we might add all the muscles of the supra-hyoid region, and those muscles of the pharynx which have attachments to the cricoid and thyroid cartilages.

The intrinsic muscles are nine in number, viz. four pairs and one single muscle. Those which exist in pairs, are the crico-thyroidei, the crico-arytenoidei postici, the crico-arytenoidei laterales, and the thyro-arytenoidei. The single muscle is the arytenoideus.

The Crico-thyroideus.

Dissection. This muscle is completely exposed by separating the larynx from the muscles by which it is covered. In order to gain a good view of the deep portion of the muscle, the lower part of the thyroid cartilage must be removed.

The crico-thyroideus (*a*, *figs.* 147. 170.) is a short, thick, triangular muscle, situated on the anterior part of the larynx, on each side of the crico-thyroid membrane, and divided into two distinct bundles. It is attached below to the cricoid cartilage on each side of the median line, to the whole of the anterior surface, and even to part of the lower border of the cartilage. From these points the fleshy fibres radiate in different directions: the internal fibres pass somewhat obliquely upwards and outwards; the middle ones very obliquely, and the lower fibres horizontally outwards, to the lower border of the thyroid cartilage (excepting to its middle portion), and to the lower margin of the corresponding lesser cornu. The greatest number of fibres are inserted into

* [The inferior vocal cords are certainly composed of elastic tissue, so also are the thyro-hyoid and crico-thyroid ligaments; and, according to M. Lauth (*Mém de l'Acad. Roy. de Méd.* 1835), the lateral crico thyroid membranes, the superior vocal cords, and the aryteno-epiglottid ligaments are also composed of this tissue, which, he says, exists even in the thyro-epiglottid, hyo-epiglottid, and glosso-epiglottid ligaments.]

the posterior surface of the thyroid cartilage; some of them are continuous with the inferior constrictor of the pharynx (*w*, *fig.* 147.).

It is covered by the sterno-thyroid muscle and the thyroid gland, and it covers the lateral crico-arytenoid and the thyro-arytenoid muscles. The inner borders of the crico-thyroid muscles are separated from each other by a triangular space, broad above and narrow below, in which the crico-thyroid membrane is visible.

Their *action* is not yet well determined. By taking their fixed point upon the cricoid cartilage, it appears to me that they would move the thyroid cartilage in such a way as to increase the antero-posterior diameter of the glottis, and thus act as tensors of the vocal cords.

The Crico-arytenoideus Posticus.

Dissection. This muscle is exposed by removing the mucous membrane from the posterior surface of the larynx.

It is a triangular muscle (*g*, *figs.* 171. 177.), situated at the back of the cricoid cartilage. Its fibres arise from the lateral depression, which we have described on the posterior surface of the cartilage, and pass in different directions; the upper fibres are the shortest, and are almost horizontal; the middle are oblique, and the lower are nearly vertical; they all converge towards the posterior and external process on the base of the arytenoid cartilage, behind the crico-arytenoideus lateralis.

Relations. It is covered by the mucous membrane of the pharynx, to which it is very loosely united, and it covers the cricoid cartilage.

Action. It is a *dilator of the glottis.* It carries the base of the arytenoid cartilage backwards, outwards, and downwards, and thus renders the inferior vocal cord tense.

The Crico-arytenoideus Lateralis.

Fig. 177.

Dissection. Remove with care one of the lateral halves of the thyroid cartilage (as in *fig.* 177.). It is impossible to separate this muscle from the thyro-arytenoideus.

This is an oblong muscle (*f*), situated deeply under the thyroid cartilage. Its fibres arise from the side of the upper border of the cricoid cartilage, in front of the crico-arytenoid articulation; from this point they proceed obliquely upwards and backwards, to be inserted into the posterior and external process of the arytenoid cartilage, by a tendon common to them, and to the thyro-arytenoideus. It is covered by the thyroid cartilage and by the crico-thyroid muscle, and it covers the lateral crico-thyroid membrane (*d*).

The Thyro-arytenoideus.

Dissection. The same as for the preceding. This muscle may be dissected from the interior of the larynx, by removing the vocal cords.

I describe the thyro-arytenoideus and the crico-arytenoideus lateralis separately, merely in accordance with custom, for in no instance, not even in large animals, such as the ox, have I ever been able to separate them completely. They have the same arytenoid insertion; their fibres are situated upon the same plane, without any line of demarcation, and they fulfil the same uses. We might, therefore, unite them under the name of the *thyro-crico-arytenoideus.*

The *thyro-arytenoideus* (*e*) is a broad muscle, very thin above, and very thick below. It arises on each side, from about the lower two thirds of the retreating angle of the thyroid cartilage. The greater number of its fibres arise

from the lower part of the angle, and form a very thick fasciculus. From these points they pass horizontally backwards and outwards, and terminate in the following manner. The thick fasciculus above mentioned is inserted into the outer surface of the anterior process of the arytenoid cartilage, and into a depression on the outer side of the base of that cartilage, between the two processes. The upper fibres are attached to the outer border of the arytenoid cartilage. In the larger animals, the upper fibres of the muscle evidently proceed to the epiglottis, and form the *thyro-epiglottideus* of some authors.

Relations. On the *outside* it corresponds with the thyroid cartilage, from which it is separated by loose and sometimes adipose cellular tissue; on the *inside* it is in contact with the vocal cords and the ventricle of the larynx. The thickest part of the muscle corresponds with the inferior vocal cord, and is almost the only cause of its projecting into the interior of the larynx. This fasciculus may even be considered as contained within the substance of the inferior vocal cord, and the two structures are so closely adherent, that great care is required to separate them. Many anatomists, indeed, have thought that the fibres of the thyro-arytenoideus terminate in the vocal cord, which they therefore regarded as the tendon of the muscle; but the cord and muscle may always be completely separated.

Action. It carries the arytenoid cartilage forwards, and would thus seem to relax the inferior vocal cord, as Haller believed: "*Cartilagines guttales* (the arytenoid) *antrorsum ducunt, glottidem dilatant, ligamentorum glottidis tensionem minuunt.*" (*Elementa Physiol.* t. iii. liv. 9. p. 387.) But if we consider the mechanism of the crico-arytenoid articulations, and the mode of insertion of the thyro-arytenoid muscles into the outer side of the bases of the arytenoid cartilages, we shall perceive that, at the same time that these cartilages are carried forwards, they undergo a partial rotatory movement, by which their anterior processes are turned inwards. The ligaments of the glottis are therefore rendered tense, and approximated towards each other. This movement may be carried to such an extent that the anterior processes may touch, and the antero-posterior diameter of the glottis be diminished accordingly.*

The thyro-arytenoideus is then both a tensor and a constrictor of the glottis. This, moreover, was the opinion of both Cowper and Albinus, but Haller attempted to refute it.†

The sudden action of the thyro-arytenoid muscle, pressing upon the ventricle of the larynx, may expel any mucus collected within it.

The Arytenoideus.

Dissection. Remove the mucous membrane and glandular masses which cover it behind. Detach it along one of its borders, so as to be enabled to examine its thickness.

The *arytenoideus* (*a*, *fig.* 171.) is a single, short, thick, trapezoid muscle, situated behind the arytenoid cartilages, and filling up the concavity on their posterior surfaces, as well as the interval between them. It arises from the whole length of the outer border of the right arytenoid cartilage, and is inserted into the corresponding part of the left. Some of the fibres arise from the upper border of the cricoid cartilage. The fibres have a triple direction, and form three layers, which have been regarded as so many distinct muscles.

The two more superficial layers are oblique, and cross each other; one passing from the base of the right arytenoid cartilage to the apex of the left, and the other following the opposite direction; they constitute the *arytenoideus obliquus* of Albinus: both of these layers are thin.

* [The effect of this will be as stated by Haller, to *relax* the vocal cords, which is considered by the latest observers to be the action of these muscles.]

† Loc. cit. "Cùm magni viri glottidem dixerint ab istis musculis arctari, experimento facto *diducere* didici. Neque potest ille ad latus cartilaginis arytænoidæ musculus terminari quin *eam rimam diducat.*"

The third and deepest layer is very thick; it is composed of transverse fibres, and forms the *arytenoideus transversus* of Albinus.

None of the fibres reach the cornicula. Under the name of the aryteno-epiglottideus, muscular fibres have been described extending from the arytenoid muscle to the margins of the epiglottis. Some fibres of the arytenoideus are also said to be continuous with the thyro-arytenoideus.

Relations. *Behind*, with the mucous membrane and some glandular masses, which adhere to the muscle by means of loose cellular tissue; *in front* it is in relation with the posterior surface of the arytenoid cartilages, and in the interval between them with a thin fibrous membrane, extending from the upper border of the cricoid cartilage to the whole extent of the inner borders of the arytenoid cartilages.

Action. It would appear, at first sight, that this muscle must forcibly approximate the two arytenoid cartilages, and therefore constrict the glottis *; but if we remember that it is attached to the outer borders of these cartilages, we shall understand that, besides drawing them together, it must produce in them such a movement as will carry their anterior processes outwards, and stretch the vocal cords, but at the same time separate them from each other. And if we call to mind that the thyro-arytenoideus occasions an exactly opposite movement, it will be understood that the simultaneous action of the two muscles must produce tension of the cords, and, at the same time, fix the processes.

Having thus obtained a knowledge of the cartilages of the larynx, the articulations by which they are united, and the muscles which move them, we shall now proceed to give a general description of this organ.

The Larynx in general.

The larynx, the general position of which has been already described, presents certain differences in its *dimensions*, depending either upon the individual, upon sex, or upon age. These differences affect both the whole of the larynx and its constituent parts. Thus, the larynx of the female may always be distinguished from that of the male, by being smaller, *i. e.* about two thirds the size of the male larynx; and by the angles and processes of its cartilages being less prominent, and their depressions less marked. These differences are connected with the characters of the voice, and affect principally the dimensions of the glottis.

The individual differences in the size of the larynx have not been thoroughly examined. The differences depending on age will be noticed when speaking of its developement.

The larynx presents for our consideration an *external* and an *internal* surface.

The external surface of the larynx — anterior region (*fig.* 170.). In the *median line* we observe a vertical ridge, formed by the angle of the thyroid cartilage; beneath this the crico-thyroid membrane, and still lower the convexity of the cricoid cartilage.

On the *sides* we find the oblique laminæ of the thyroid cartilage, a portion of the cricoid covered by the crico-thyroid muscle, and the thyro-cricoid articulation.

Subcutaneous in the median line, where it is only separated from the skin by the linea alba of the neck, the external surface of the larynx is covered on each side by the muscles of the sub-hyoid region, the inferior constrictor of the pharynx, and the thyroid gland. The superficial position of the surface enables us to examine its different parts through the integuments, and renders it liable to wounds. Its still greater proximity to the skin in the median line has suggested the operation of laryngotomy.

Posterior region (*figs.* 141. 171.). In the *median line* we observe a prominence

* [When acting together with the lateral crico-thyroid muscles, this is certainly their action.]

like a small barrel, on either side of which the thyroid cartilage projects. This prominence is formed by the back of the cricoid, and by the arytenoid cartilages, the expanded portion corresponding with the bases of the latter, which are covered by folds of a pale mucous membrane. Under this membrane we find, proceeding from above downwards, the arytenoideus muscle, the vertical ridge of the cricoid cartilage, the crico-arytenoidei postici, and the crico-arytenoid articulations.

On *each side* of the barrel-shaped prominence is a deep angular groove, formed by the meeting of two flat surfaces, which are separated above, but approximated below; along these grooves it is supposed that liquids flow during deglutition. The external wall of each groove is formed by the posterior surface of the thyroid cartilage, the os hyoides, and the thyro-hyoid membrane. The internal wall is formed by the upper and lateral part of the barrel-shaped prominence. The grooves are lined by a closely adherent mucous membrane; and it should be observed that they exist only on a level with the arytenoid cartilages, and consequently in this region alone is the larynx protected by the thyroid cartilage, the posterior borders of which rest upon the vertebral column. The back of the cricoid cartilage is on a level with the posterior borders of the thyroid (*fig.* 174.), and like them rests upon the vertebral column.

The internal surface of the larynx. The internal surface of the larynx does not correspond either in shape or dimensions with its outer surface; and this depends principally on the fact, that the retreating angle of the thyroid is the only part of that cartilage which enters into the formation of the laryngeal cavity, the lateral laminæ being altogether unconcerned in it.

Cylindrical below, where it is formed by the cricoid cartilage, the cavity of the larynx is prismatic and triangular above, where it is constituted by the epiglottis in front, the arytenoid cartilages and the arytenoid muscle behind, and on the sides by the two mucous folds which extend from the margins of the epiglottis to the arytenoid cartilages. The dimensions of the lower of these two portions of the laryngeal cavity undergo no change, always remaining the same as those of the cricoid cartilage; while the upper, on the contrary, which is broadest in front, varies much in size in consequence of the mobility of the epiglottis and the arytenoid cartilages. Between these two portions, and about the middle of the larynx, a fissure exists, which is narrower than the rest of the cavity, and oblong from before backwards; this is the *glottis*, or *vocal apparatus* properly so called. It can be seen without any dissection, by looking down into the larynx (*fig.* 178.), and requires a very particular description.

The glottis, or vocal apparatus. The glottis (γλωττὶς, from γλώσση, the tongue), frequently confounded with the superior orifice of the larynx*, is a triangular opening or fissure (*o*, *fig.* 178.) (*rima*), elongated from before backwards, and included between the vocal cords of the right and left sides. It represents two isosceles triangles, placed one above the other, and having perfectly equal borders, the base of each being directed backwards, and its apex forwards. The lower isosceles triangle is formed by the *inferior vocal cords* (*r*), and the upper one by the superior vocal cords (*s*). The inferior vocal cords are situated nearer to the axis of the larynx than the superior, so that a vertical plane let fall from the latter would leave the inferior vocal cords on its inner side. Many authors limit the term *glottis* to the lower triangle. This view is supported by the absence of the superior vocal cords in a great number of animals, the ox in particular.

Fig. 178.

* This error is perhaps to be attributed to the use of the word *epiglottis*, so much do words influence our ideas. It was committed even in Haller's time, who says, "*Etiam hoc (laryngis) ostium non benè pro glottide sumitur.*"

Dimensions of the glottis. The glottis is the narrowest part of the larynx, and hence the danger from the introduction of a foreign body into it, and from the formation of false membranes in this situation. The only action of the intrinsic muscles of the larynx is to dilate or contract the opening of the glottis. We have seen that, with the exception of the crico-thyroidei, they are all in some measure collected round the crico-arytenoid articulation, the movements of which determine the dimensions of the glottis.

The individual differences which constitute the tenor, baritone, or bass voices in singing depend upon the size of the glottis; to which, also, must be attributed the difference between the male and female voice, and the change produced in its tone at the time of puberty. A deep voice coincides with a large glottis, and a shrill voice with a small one. In the adult male the antero-posterior diameter of the glottis is from ten to eleven lines, in the female it is only eight lines; in the male the greatest transverse diameter is from three to four lines, in the female from two to three lines.*

From these dimensions it may be understood how a *louis d'or* might pass edgewise through the glottis, and thus fall into the trachea. In a case of this kind, most of those who were called in consultation rejected the idea of the presence of the coin in the windpipe, because, said they, the glottis cannot admit it. The patient died in about a year, and the *louis d'or* was found in the trachea.

Ventricle of the larynx. Between the superior and inferior vocal cords of each side there is a cavity, called the *ventricle* or *sinus of the larynx* (*v*, *fig.* 176. 178.); it is oblong from before backwards, and of the same length as the cords; its depth is determined by the interval separating the cords from the thyroid cartilage, or rather from the thyro-arytenoid muscle, which forms the bottom of the corresponding ventricle. The opening of the ventricle is somewhat narrower than the bottom, is elliptical in its longest diameter, and has admitted the introduction of a foreign body. To each ventricle there is a supplementary cavity, which is accurately described and figured in the works of Morgagni.† This cavity resembles in shape a Phrygian cap; it has a broad base opening into the ventricle, and a narrow apex; it is found at the anterior part of the ventricle, and is prolonged on the outer side of the superior vocal cord between it and the thyroid cartilage, upon the side of the epiglottis. Its dimensions vary much. In one case its vertical diameter was six lines, and it was divided into two parts by a transverse band.

The circumferences of the larynx. The superior circumference of the larynx (*fig.* 178.) is much wider than the inferior, and presents the following objects: —the superior angular border of the thyroid cartilage, and the great cornua in which it terminates; behind the thyroid cartilage, the epiglottis (*i*); and between the cartilage and the epiglottis, a small triangular space filled by a compact fatty mass, which has been incorrectly described as the *epiglottid gland.* I have already said that this fatty mass is bounded above by a fibrous membrane, extending from the epiglottis to the posterior surface of the os hyoides.

Behind the epiglottis, we find *the upper orifice of the larynx*, which must not be confounded with the glottis; it slopes obliquely from before backwards and from above downwards, having the form of a triangle, with its base directed forwards and its apex backwards, consequently in the opposite direction to the glottis. This orifice is formed in *front* by the free margin of the epiglottis, which is slightly notched; on each *side* by the upper part of the lateral margin of the epiglottis, and by the free edge of the *aryteno-epiglottid fold* (*b*); and *be-*

* These measurements are taken at the level of the inferior vocal cords; the transverse diameter is rather longer opposite the superior vocal cords.

† I first saw this cavity in a patient affected with laryngeal phthisis, in whom it was very much developed. I then examined the larynx in other individuals, and found it to be constant. I did not then know that Morgagni had pointed it out and figured it. (*Advers.* i. *Epist. Anat.* viii.)

hind by the cornicula laryngis, and by the summits of the arytenoid cartilages (*a*), and the deep notch between them.

The superior orifice is the widest part of the larynx, and admits foreign bodies which cannot pass through its lower portion. The epiglottis when depressed generally covers it completely, and may even overlap it at the sides.

The *inferior circumference of the larynx* is perfectly circular, is formed by the cricoid cartilage, and is continuous with the trachea.

The mucous membrane and glands of the larynx. The mucous membrane of the larynx is a continuation of that of the mouth and pharynx. The larynx presents the only example in the body of an organ, part of whose external surface, namely the posterior, is covered with mucous membrane; and this depends upon the circumstance of its forming part of the parietes of the pharynx.

The mucous membrane is disposed in the following manner:—From the base of the tongue it is reflected upon the anterior surface of the epiglottis, forming the three glosso-epiglottid folds already described, one in the middle and one on each side; it adheres pretty closely to the epiglottis, is reflected over its free margin, covers its posterior surface, and penetrates into the larynx; on each side it passes from the epiglottis to the arytenoid cartilages, and becomes continuous with the pharyngeal mucous membrane, which covers the back of the larynx. At the superior orifice of the larynx it is reflected upon itself to form the aryteno-epiglottid folds, which constitute the sides of the supra-glottid region of the larynx; it then covers the superior vocal cord, and lines the ventricle, sending a prolongation into its supplementary cavity. In the ventricle it is remarkable for its slight adhesion to the subjacent parts. It is reflected from the ventricle upon the inferior vocal cord; there, as well as opposite the superior cord, it is so thin, that it does not conceal the pearly appearance of the ligament beneath, to which it adheres so closely that it is difficult to separate them. Lastly, it covers the internal surface of the cricoid cartilage, and the middle and lateral crico-thyroid membranes.

The laryngeal mucous membrane is characterised by its tenuity, its adhesion to the parts beneath it, and by its pale pink colour.* It is perforated by the openings of a number of mucous glands. Its extreme sensibility, especially at the upper orifice and in the supra-glottid portion of the larynx, is well-known.† The aryteno-epiglottid folds, which include the ligaments of the same name, and some muscular fibres in the larger animals, are remarkable for the great quantity of very loose cellular tissue which they contain: this fact explains their liability to a serous infiltration, called œdema of the glottis, which proves rapidly fatal.

The glands of the larynx. The glands of the larynx are the epiglottid and the arytenoid. The thyroid gland, or body, cannot be considered as belonging to the larynx; if it belongs to any organ, it must be to the trachea.

The epiglottid glands. The name of epiglottid gland is generally given to the fatty mass already described as being situated between the thyroid cartilage and the epiglottis; and it has even been asserted that it opens by special ducts on the posterior surface of the epiglottis. But there is no other epiglottid gland, besides those situated in the substance of the epiglottis, which is perforated with innumerable holes for their reception: these small glands are so numerous, that Morgagni (*Advers.* i. 2.; v. 68.) regarded them as forming a single gland; they all open upon the laryngeal surface of the epiglottis by

* [The epithelium of the laryngeal mucous membrane is, in the greater part of its extent, columnar and ciliated. The cilia urge the secretion upwards; according to Dr. Henlé, they extend higher up in front than on each side and behind; on the sides, for example, as high as the border of the superior vocal cords, or about two lines above them, and in front upon the posterior surface of the epiglottis, as high as its base or widest portion. Above these points the epithelium gradually assumes the laminated form, like that in the mouth and pharynx.]

† It has been observed, in experiments upon animals and in introducing the canula after the operation of laryngotomy, that the sensibility of the mucous membrane beyond the glottis is much less acute.

very distinct orifices, from which a considerable quantity of mucus can be pressed.

The arytenoid glands. These were well described by Morgagni, who very properly considered them as forming a single glandular mass, situated in the substance of the aryteno-epiglottid fold. They are arranged in two lines, united at an angle, like the letter L *; the vertical line runs along the anterior surface of the arytenoid cartilage and its corniculum, and produces a slight prominence, perfectly distinct from that made by the cartilages; the horizontal line is less prominent, and is situated in the superior vocal cord. The arytenoid glands open separately upon the internal surface of the larynx.

Vessels and nerves. The *arteries* are derived from the superior thyroid, a branch of the external carotid, and from the inferior thyroid, a branch of the subclavian. The *veins* enter the corresponding venous trunks. The *lymphatic vessels*, which are little known, terminate principally in the glands of the supra-hyoid region, if we may judge from the frequency of their inflammation in cases of acute laryngitis, &c.

The *nerves* are branches of the pneumogastric, viz. the superior and the inferior, or *recurrent laryngeal.* The superior laryngeal nerves are not exclusively distributed to the muscles called constrictors of the glottis (the arytenoideus and the crico-thyroidei); nor do the inferior laryngeals belong exclusively to those called dilators (the crico-arytenoidei postici and laterales, and the thyro-arytenoidei), as a celebrated physiologist has affirmed. (See Neurology.) The peculiar rotatory movement of the arytenoid cartilages somewhat interferes with any classification of these muscles into dilators and constrictors.

Developement. The evolution of the larynx is remarkable in this respect, that after having attained a certain size, it undergoes no appreciable change until the time of puberty. The ventricles are as yet so slightly developed that their existence has been denied. The prominence of the os hyoides in some measure conceals that of the larynx. M. Richerand (*Mém. de la Société Méd. d' Emulation*, tom. iii.) has proved that there is no very remarkable difference between the larynx of a child at three years of age and of one at twelve. Up to the age of puberty the larynx presents no trace of the sexual differences, which afterwards become so evident; and to these anatomical conditions are owing the shrillness and uniformity of the voice in the youth of both sexes.

At the period of puberty, at the same time as the genital organs, the larynx increases so rapidly as to attain its full developement in the space of one year; the voice then loses its uniformity, and acquires its peculiar timbre and quality, and then also the sexual differences in the vocal apparatus become manifest.

Is it from an unequal developement of the different parts of the larynx, or from want of a certain degree of education, that the voice at this period is so discordant, especially in singing, or *breaks*, as it is said?

The simultaneous developement of the genital organs and the larynx has led to the opinion, that they stand to each other in the relation of cause and effect; and observation has established that the vocal apparatus is in some measure under the influence of the generative organs; for in eunuchs the larynx remains as small as it is in the female. (M. Dupuytren, *Mém. de la Soc. Phil.* tom. ii.)

At the age of puberty the size of the glottis is increased by one third in the female, and is nearly doubled in the male. After puberty, any changes which the larynx may undergo are the result of exercise, not of developement properly so called.

Ossification of the cartilages of the larynx is not always the effect of age. I have seen it at the thirtieth year, quite independently of disease. Chronic inflammation of the larynx induces a premature ossification of the cartilages. The thyroid has the greatest tendency to this change, then the cricoid, and lastly the arytenoid cartilages: I have never observed it in the epiglottis.

* "Gnomonis, sed obtusanguli figuram utervis acervus habet." (*Haller.*)

Functions. The larynx is the organ of voice. Numerous experiments upon living animals, and many surgical facts, show that the vocal sound is produced exclusively in the larynx. The lungs, the bronchi, and the trachea perform, with regard to the voice, the office of an elastic conductor of air, capable of contraction and dilatation, of shortening and elongation. The thorax acts like a pair of bellows, by which the air is driven into the larynx with any wished for degree of force; and hence the quantity of air passing through the larynx, and the rapidity with which it moves, may vary to a very great extent.

What then is the mechanism of the voice? Is it the same as that of a horn (*Dodart*), of a stringed instrument (*Ferrein*), of a flute (*Cuvier*), of a reed instrument (*Biot* and *Magendie*), or of a bird-call* (*Savart*)? Is it produced by the vibration of the tense vocal cords, or merely by the vibration of the air whilst passing through a narrow opening, which is itself incapable of vibrating? We shall leave these questions to the decision of physiologists. It is sufficient for our purpose to know that the action of the muscles of the larynx and the arrangement of the vocal apparatus are perfectly fitted to produce either dilatation or contraction of the glottis; and such is the mechanism of this part, that, from the rotatory movement of the arytenoid cartilages, the vocal cords are always rendered tense, whatever may be the other actions of the muscles.

The voice as it issues from the larynx is simple, for the larynx is, with regard to the voice, what the mouth-piece is in the flute, or the reed in the bassoon; but during its passage through the vocal tube, composed of the epiglottis, the pharynx, the isthmus of the fauces, the mouth, and the nasal fossæ, the voice becomes modified.

According to a very ingenious theory of M. Magendie, the epiglottis resembles those soft and moveable valves which M. Grénié places in the pipes of an organ, to enable the sound to be increased without modifying the tone.

The isthmus of the fauces resembles the superior larynx of birds, which consists of a contractile orifice that can be diminished, and even closed at pleasure; and it is principally owing to this mechanism, that the small glottis of birds can execute such an extensive range of notes. We know, in fact, that the tone of a wind instrument is reduced an octave lower, by completely closing the lower orifice of the tube, and that when it is only partially closed, the tone is depressed in proportion. Now the isthmus of the fauces acts exactly like the superior larynx of birds. On watching a person who wishes to utter a very low note, we see that he depresses and flexes the head slightly upon the neck, so as to approximate the chin to the thorax: by this means the vertical diameter of the isthmus of the fauces is diminished, the larynx being carried upwards, whilst the velum palati is depressed: and from this we may judge of the important part performed by the velum, in producing modulations of the voice.

If to this we add the changes which may be effected in the length and diameter of the pharynx (see *Pharynx*), and if we remember that by diminishing by one half the length or diameter of the tube or body of a wind instrument, its tone is raised one octave, we shall be able to understand how the human voice can execute so extensive a scale of notes, although the glottis is so small. The voice is also modified while traversing the buccal and nasal cavities.

Do the *nasal fossæ* favour the resonance of the voice? or does the air when passing through them, merely give rise to certain sounds denominated nasal? The latter opinion, which is supported by Mr. Gerdy, appears to me the most consistent with facts. MM. Biot and Magendie had already correctly

* A bird-call is a cavity with elastic walls, perforated upon the two opposite sides. The cavity is represented by the ventricles, and the openings by the intervals between the vocal cords. If a tube capable of contracting and dilating be fitted to such an instrument, an infinite variety of sounds may be produced.

observed that the voice becomes nasal, only when it traverses these passages.

The voice becomes articulate in passing through the mouth, *i. e.* the vocal sound is interrupted, and modified by the more or less rapid percussion of the lips and tongue against the teeth and the palate.

Articulate voice is very distinct from speech. Animals which differ much from man in the conformation of their vocal organs, the parrot for example, may be made to articulate; but speech is the peculiar attribute of man, because he alone is possessed of intelligence.

The Thyroid Gland.

The *thyroid gland*, or thyroid body, is a glanduliform organ, the uses of which are unknown: it is situated, like a crescent with its concavity directed upwards, in front of the first rings of the trachea, and upon the sides of the larynx.

In describing this organ in connection with the larynx, I follow the usual custom, which has arisen not from any direct relation between their functions, but from their contiguity to each other.

The thyroid body varies much in *size* in different individuals; there are few organs which present greater varieties in this respect.

The sexual differences in the size of this organ, like all those relating to the vocal apparatus, are very well marked, but in an inverse manner, that is to say, the thyroid body is larger in the female, in whom it forms a rounded projection, which assists in making the thyroid cartilage in that sex appear still less prominent.

Climate, and more especially certain qualities in the water used as drink, have a remarkable influence upon its size, which, in many cases of goître, is enormous.

These differences in size affect either the whole of the gland equally, or only one lobe, or occasionally the middle portion alone.

The *weight* of the thyroid body, which is about an ounce, may be increased to a pound and a half, or even more.

Form. The thyroid body is generally composed of two lateral *lobes* or *cornua*, united by a contracted portion, flattened from before backwards, and called the *isthmus*. The varieties in shape principally affect the isthmus, which may be very narrow, long or short, regular or irregular, or entirely absent, or it may be as thick and as long from above downwards as the lobes themselves. I have seen one case in which the thickest part of the thyroid gland was in the middle, and the lobes terminated above in a very narrow point.

The opinion of the ancients, and which is also met with in Vesalius, that the human subject has two thyroid glands, no doubt arose from the narrowness or absence of the isthmus, or rather from the separation and complete independence of the two lobes in a great number of animals. The surface of the thyroid body is smooth and well defined, and sometimes divided into lobules by superficial furrows.

We shall examine in succession the *relations* of the middle and lateral portions: —

The *middle portion* or *isthmus* is convex in *front*, and is separated from the skin by all the muscles of the sub-hyoid region. *Behind*, where it is concave, it is in contact with the first rings of the trachea. Moreover, this middle portion descends to a greater or less distance in different subjects, and sometimes so low, that there is not room to perform tracheotomy between it and the sternum.

Each *lateral lobe* is convex in *front*, and corresponds with the muscles of the sub-hyoid region: in particular I ought to mention the sterno-thyroid, by which it is directly covered, and the breadth of which seems to be propor-

tioned to the size of the lobe: in many cases of goître, I have seen this muscle twice or three times as broad as in the natural state. *On the inside*, each lateral lobe is concave, so as to be applied to the side of the trachea and cricoid cartilage, to the lower and lateral part of the thyroid cartilage, to the lower part of the pharynx, and to the upper part of the œsophagus. The two lobes, together with the middle portion or isthmus, form a half or sometimes three-fourths of a canal, which embraces all those parts; an extremely important relation, which explains how, in certain goîtres, the trachea is flattened on the sides, deglutition is impeded, and true asphyxia by strangulation is the final result. *Behind*, each lateral lobe corresponds with the vertebral column, from which it is separated, on the outside, by the common carotid artery, the internal jugular vein, and the pneumogastric and great sympathetic nerves, which, according to the size of the gland, are either covered by it, or are merely in relation with its outer surface.

The *upper extremity* of each lateral lobe terminates in a point, and hence the two-horned figure assigned to the thyroid body; it is situated on the inside of the carotid artery, in contact with the lateral and back part of the thyroid cartilage, and sometimes extends nearly to its upper border. Its *lower extremity* is thick and rounded, descends to a greater or less distance in different individuals, and corresponds to the fifth, sixth, or seventh rings of the trachea: it is situated between the trachea and the common carotid. The inferior thyroid artery enters the gland at its lower extremity.

Its *upper border* is concave and notched in the middle; the superior thyroid arteries run along it. A prolongation extends from this border, which has been correctly represented by Bidloo, and named the *pyramid* by Lalouette. It almost always exists; it passes perpendicularly upwards, either on the right or left side of the median line, and presents numerous varieties in several respects. Thus it varies in its origin, sometimes arising from the isthmus, and sometimes from one of the lobes at one side of the isthmus; also in its termination, sometimes ending opposite the notch in the upper border of the thyroid cartilage, sometimes opposite the thyro-hyoid membrane, and at other times even on a level with the body of the os hyoides; but always firmly adherent either to the membrane or the bone. It also varies in its structure; sometimes it is a fibrous cord, and sometimes a reddish linear band, which has all the appearances of a muscular fasciculus, and has even been described as a muscle; it often consists of a series of granules arranged in a line; sometimes again we find, in the middle, or at one end of the cord, a glanduliform enlargement, exactly resembling the tissue of the thyroid gland; lastly, it may be double, or bifurcated, or even completely wanting; in which case, however, there exists a glanduliform mass of a certain height. This prolongation, in which I and many others have in vain attempted to find an excretory duct, is evidently of a compact nature. Is it the remains of a fœtal structure, or the trace of a normal disposition in some animals?

The *lower border* of the thyroid body is convex, more or less deeply notched in the centre, and is in contact with the inferior thyroid arteries.

Structure. The proper tissue of the thyroid gland is of a variable *colour*, sometimes resembling the lees of port wine, and sometimes of a yellowish hue. It is of tolerably firm *consistence*, and feels granular. This organ presents all the anatomical characters of glands, and like them may be separated by dissection into glandular grains; but with this difference, that these grains communicate with each other, whilst, in ordinary glands, they are independent. The communication of the glandular grains may be shown in the following manner: if the tube of a mercurial injecting apparatus be inserted into the thyroid gland, the mercury will enter into and distend the cells, and after a certain time all the grains will be injected: it is easy to satisfy the mind that the mercury is not infiltrated into the cellular tissue, but is contained in the tissue of the gland itself, in the centre of the granulations. The right and left

lobes do not communicate, but all the granulations of each lobe communicate with each other.

The thyroid gland has, therefore, a vesicular structure; and we have seen that the glandular grains of all glands are spongy and porous, and that the products of their secretion may be accumulated in these pores.

The glandular nature of the thyroid body is also shown by the viscid, limpid, yellowish fluid which pervades it in certain subjects, and which may be collected in sufficient quantity for chemical analysis; and also by the retention of this matter within a greater or less number of the vesicles when their orifices of communication with the neighbouring vesicles become obliterated.

But in connection with this view regarding its glandular nature, we seek in vain for an excretory duct. If we examine the trachea and the larynx, or lay open the œsophagus, and then press the thyroid gland, we shall see that no fluid escapes into those canals. It has been asserted, indeed, that the excretory duct of the thyroid gland terminated in the *foramen cæcum* of the tongue, in the ventricles of the larynx, or in the trachea opposite its first ring; but, after the example of Santorini, we are compelled to reject these fancied and too hastily announced discoveries.

I may here notice the intimate adhesion of the side of the thyroid gland to the first ring of the trachea. This can be very well shown by detaching the gland from behind forwards: it is of a fibrous nature, and I have sometimes thought that I saw a duct in the centre of it, passing through the membrane which connects the trachea with the cricoid cartilage, though I have never been able satisfactorily to demonstrate it.

Still I do not think that the absence of an excretory duct should remove the thyroid from amongst the glandular organs; for I believe that there exist in the body glands without excretory ducts, as the thymus, the suprarenal capsules, and the thyroid body. The secretion of the gland is entirely absorbed, and fulfils certain unknown uses.

Arteries. The size and the number of the arteries distributed to the thyroid gland indicate that something more than a mere nutritive process must be carried on in it. The arteries are sometimes four, sometimes five in number: two superior arise from the external carotid; two inferior from the subclavian, and the fifth, or the thyroid artery of Neubauer, where it exists, arises from the arch of the aorta.

The *veins* are proportionally as large as the arteries, and form so considerable a plexus in front of the trachea, as, in certain cases, to have prevented the completion of the operation of tracheotomy.

The *lymphatic vessels* terminate in the cervical lymphatic glands.

The *nerves* are derived from the pneumogastrics, and the cervical ganglia of the sympathetic.

A thin cellular membrane envelopes the gland, and sends very delicate prolongations into its substance, where we find a very firm cellular tissue, always destitute of fat.

Developement. The thyroid gland is developed in two lateral halves, which are afterwards united by a median portion. It is not uninteresting to remark, that this disposition, which is transitory in the fœtus, represents the permanent condition of the gland in a great number of animals. During intra-uterine life and infancy it is relatively larger than at subsequent periods. Nevertheless, the changes which it afterwards undergoes are not to be compared with those that occur in the thymus; and we cannot say, as of the latter structure, that the existence of the thyroid body has any peculiar relations with fœtal life.

Functions. It is a secreting organ, but the uses of its fluid are not known.

THE GENITO-URINARY ORGANS.

I have thought it proper to describe the *genital* and the *urinary organs* together, because, although their functions are very distinct, yet they have the most intimate anatomical, physiological, and pathological connections.

THE URINARY ORGANS.

Division. — *The Kidneys and Ureters.* — *The Bladder.* — *The Suprarenal Capsules.*

The urinary organs form a very complex secretory apparatus, consisting of two secreting organs, the *kidneys*; of two provisional reservoirs, the *calyces* and the *pelvis* of each kidney; of two excretory ducts, the *ureters*; of a second and final reservoir, the *bladder*; and lastly, of a second and final excretory canal, which, in the male, is common to both the genital and the urinary organs, viz. the *canal of the urethra.*

The Kidneys.

The *kidneys* (νεφροί) are glandular organs, intended to secrete the urine.

They are deeply *situated* (*k k*, *fig.* 199.) in the lumbar region, hence called the *region of the kidneys*, on each side of the vertebral column, externally to the peritoneum, which merely passes in front of them; they are surrounded by a great quantity of fat, and, as it were, suspended by the vessels which pass into and emerge from them.

Fixed firmly in this situation, they are but little liable to displacement. Most of the changes in their position are congenital. The right kidney generally descends a little lower than the left, doubtless on account of the presence of the liver. One of the kidneys may not uncommonly be found in front of the vertebral column, or even in the cavity of the pelvis; and this unusual arrangement may, in certain cases, render diagnosis very obscure.* I have frequently found the right kidney in the corresponding iliac fossa in females who had been in the habit of wearing very tight stays. This displacement happens when the pressure of the stays upon the liver forces the kidney out of the depression in which it is lodged in the lower surface of that organ.

Number. The kidneys are two in number. It is not very uncommon to find only one, which is almost always formed by the union of the two, by means of a transverse portion crossing in front of the vertebral column, and having its concave border directed upwards.

Sometimes the two united kidneys are situated in the right or left lumbar region, or in the cavity of the true pelvis. Cases of union of the two kidneys should be distinguished from those in which one of them is atrophied.

Again, Blasius, Fallopius, Gavard, &c. relate examples of individuals having three kidneys; in some of these cases, two were situated upon the same side, in others the supernumerary kidney was placed in front of the vertebral column.

Size. The kidney is not subject to such great variations in size as most other organs. Its ordinary dimensions are from three and a half to four inches in length, two inches in breadth, and one inch in thickness. Its *weight* is from two to four ounces.† I have found them more than three times their or-

* I lately had in my wards a female labouring under hectic fever, of which I could detect no cause, either in the thorax or the abdomen. Upon opening the body, after death, I found the two kidneys united, situated in the true pelvis, behind the rectum, and projecting a little above the brim. They contained a large quantity of pus, which escaped by the rectum.

† [According to M. Rayer, the average weight of the kidney in the male is 4½ ounces, in the female 3¾ ounces: he also states that the left kidney is almost always larger and heavier than the right.]

dinary size in a diabetic patient. When one kidney is atrophied, the other becomes proportionally enlarged, sometimes even to twice the usual dimensions. Atrophy of the kidney may be so extreme as to reduce it to a drachm and a half or two drachms in weight, and make it appear to be lost among the surrounding fat; but the presence of this fat distinguishes such a case from one of congenital absence of the kidney.*

Density and colour. The tissue of the kidney is harder than that of other glands. Its *fragility* accounts for its laceration by direct violence, or by a concussion produced by a fall from a great height.

Its *colour* is that of the lees of red wine, somewhat analogous to that of the muscular tissue, but offers several different shades.

Figure. The shape of the kidney may be well compared to a bean, with the hilus turned inwards. This form enables us to consider its two surfaces and its circumference.

Relations. The *anterior surface* of the kidney is directed slightly outwards; it is convex †, and is covered by the lumbar colon, but sometimes only by the peritoneum, the gut lying to its inner side; on the left side it is also in relation with the spleen and the great tuberosity of the stomach, and on the right side with the liver and the second portion of the duodenum.

The relations of the right kidney with the liver are more or less extensive; sometimes it is entirely covered by the liver; in other instances it is inclined downwards, and has no relation with that organ. The gall-bladder sometimes lies upon the anterior surface of the right kidney through the whole of its extent. Lastly, I have seen the kidney in immediate relation with the parietes of the abdomen, through which it could be easily felt.

As practical inferences from these relations, we would notice the difficulty of exploring the kidneys from the anterior surface of the abdomen, on account of their deep situation, also the possibility of an abscess of the kidney opening into the colon.

The *posterior surface* is less convex than the anterior, and is turned inwards; it corresponds with the quadratus lumborum, from which it is separated by the anterior layer of the fascia of the transversalis muscle; with the diaphragm, which separates it from the two or three lower ribs; and with the psoas, which intervenes between it and the vertebral column. These relations explain the possibility of exploring the kidney in the lumbar region through the quadratus lumborum, account for abscesses of the kidney opening in the lumbar region, and for the escape of renal calculi in the same direction, and form the grounds on which the operation of nephrotomy has been proposed. It is of importance to remark, that the relations of the kidneys with the ribs are variable in extent, and that sometimes they do not pass beyond the last rib.

The *circumference* of the kidney presents an external border, convex, semi-elliptical, and directed backwards; an internal border, directed forwards, and deeply notched in the middle to form the *fissure of the kidney* (*hilus renalis, h, fig.* 179.). This notch is more marked behind, where it corresponds with the pelvis of the kidney, than in front, where it corresponds with the renal vein; it is from fifteen to eighteen lines in depth.

If we separate the edges of this fissure, we expose a deep cavity containing fat, and called the sinus; in which are seen the pelvis of the kidney (*p*), the calices (*c c c′*), and the divisions of the renal artery and vein.

The upper end of the kidney is directed inwards, and is more or less completely embraced by the suprarenal capsule; it is generally larger than the lower end, which is directed slightly outwards, and projects beyond the last rib.

* I do not speak here of enlargement of the kidneys from disease. Many examples of extreme enlargement will be found in my work on *Pathological Anatomy*, liv. i. xviii.

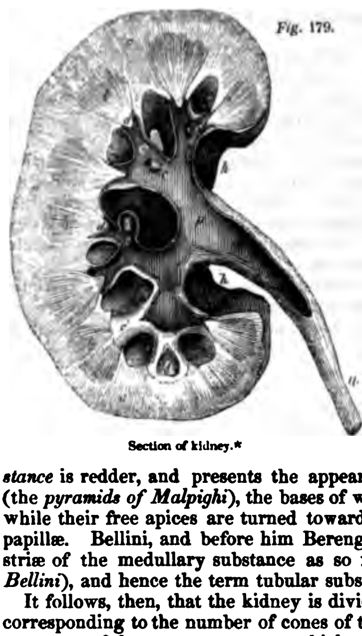
† Not unfrequently the fissure of the kidney is found on the anterior surface of that organ. In one case of this kind the right kidney occupied the right iliac fossa; it had two arteries, a superior, which proceeded directly to the fissure, and an inferior, arising from the angle of the bifurcation of the aorta, in front of the middle sacral artery, and terminating at the lower extremity of the kidney.

Structure. Make a vertical section of the kidney from its convex to its concave border. Detach the proper capsule in the same direction. Inject the arteries, veins, and ureter, in different kidneys, and also in the same kidney. Inject also the uriniferous ducts.

The proper coat. The kidney has no peritoneal covering. The remarkable fatty mass in which it is embedded is called the *fatty capsule* of the kidney. Besides this, it is provided with a proper fibrous coat, the external surface of which adheres to the fatty tissue, by means of fibrous lamellæ passing through it; its internal surface is adherent to the tissue of the kidney, through the medium of a number of small prolongations, which are very easily lacerated.

The tissue of the kidney. The kidney differs from other glands, all of which present a homogeneous and granular texture, in being composed of two substances; one of these is external, *cortical*, or *glandular* (*a a*), the other internal, *medullary*, or *tubular* (*b b b*). Some anatomists have described a third substance, the *mamillated;* but the papillæ (*d d*) of which it is composed belong to the tubular substance.

Fig. 179.



Section of kidney.*

The following is the respective arrangement of these two substances:—

The *cortical substance* forms a soft, reddish, sometimes yellow layer, of a granular appearance, and about two lines in thickness, which occupies the surface of the kidney, and sends prolongations, in the form of pillars or septa from one to three lines thick, between the cones of the tubular substance.

The *tubular* or *medullary substance* is redder, and presents the appearance of striated cones or pyramids, (the *pyramids of Malpighi*), the bases of which adhere to the cortical substance, while their free apices are turned towards the sinus, where they appear like papillæ. Bellini, and before him Berenger di Carpi, considered the fibres or striæ of the medullary substance as so many uriniferous tubes (the *tubes of Bellini*), and hence the term tubular substance.

It follows, then, that the kidney is divided into a number of compartments, corresponding to the number of cones of tubular substance; there are from ten to twenty of these compartments, which represent the temporary lobules of the human fœtal kidney, and the permanent lobules in the kidneys of the greater number of animals.†

The kidney, therefore, is formed by the union of a greater or less number of small kidneys, applied together, and connected within a common investment. We shall see presently, that, in reference to the circulation, these small kidneys are entirely independent of each other. Although the distinction between the two substances is well marked, it is easy to see that some of the fibres or striæ of the tubular structure penetrate the cortical substance in a flexuous course, and reach the surface of the organ. This fact was clearly shown by Ferrein, who considered the striæ to be the excretory ducts of the granules. These cortical and flexuous portions of the tubes, which become straight as soon as

* This figure is a *plan*, not an actual representation of the structure of the kidney.
† In some animals the kidney resembles a bunch of grapes.

they reach the medullary substance, are termed the *cortical ducts*, or the *convoluted tubes of Ferrein*.

Ferrein having examined the tubes of Bellini under the microscope, believed that each of them formed a pyramid analogous to those of the tubular substance, and that each of these secondary pyramids consisted of about a hundred ducts; hence the tubes of the tubular substance have been named the pyramids of Ferrein *, in contradistinction to the pyramids of Malpighi.

We shall now examine the structure of the tubular and the cortical substance.

Structure of the tubular substance. The tubular substance, which at first sight looks like muscular tissue, from its red colour and arrangement in lines, evidently consists of tubes or ducts.

In fact an examination under the simple microscope, of a section made perpendicularly to the axis of the tubes, demonstrates the existence of a number of small openings, each corresponding to a tube; and if, while the eye is fixed upon the section, the kidney be compressed, urine will be seen to exude from all points of the cut surface. Direct injection of the ducts, by means of a tube containing mercury, introduced at hazard into the tubular substance, will fill all the tubes in whatever direction the instrument may be directed. The ingenious experiment performed by Galvani, who tied the ureters of birds, and by this means obtained an injection of the tubes with the white matter of their urine, leaves no doubt of the existence of these tubes. Lastly, the tubes themselves are collected together in the papillæ, and open either over their entire surface, or in a small depression which sometimes exists at their summits.

Fig. 180.

Magnified sixty times.‡

Structure of the cortical substance. The cortical substance is tubular and granular. The granules are regularly disposed around the convoluted tubes of Ferrein.†

On examining a thin slice of uninjected kidney by the simple microscope, we perceive a great number of oval and spheroidal granules (*c''*, *fig.* 180.), the *acini* of Malpighi, which may be separated from each other by maceration; and those granules which have been cut through present that spongy appearance, resembling the pith of the rush, which seems to belong to all glands. When the section is vertical, these corpuscules are seen appended to the tubes of Ferrein, like grapes upon their stalk.§

Vessels and nerves. The *renal artery* is re-

* See note, *infrâ*.

† According to Ferrein, these convoluted tubes form, by their numerous anastomoses, a network, in the meshes of which the granules are contained.

‡ This is a plan, rather than an actual representation.

§ [The uriniferous tubes, commencing at their orifices upon the surface of the papillæ, pass up into the tubular portion of the kidney, dividing and subdividing dichotomously several times (*a*, *fig*. 180.), so as to constitute fasciculi of straight and radiating tubes: these are the pyramids of Ferrein, a considerable number of which are united to form one of the pyramids of Malpighi (*b*, *fig*. 179.). At the base of the latter the fasciculi spread out, and the straight tubes become the convoluted tubes of the cortical substance (*fig*. 180.).

In the human kidney, the tubuli uriniferi are said by Weber to be of a nearly uniform diameter throughout their entire course (averaging $\frac{1}{350}$th of an inch); and all appeared to him to end in *loops* (*b b*), none in free and closed extremities (as at *b'*): according to Krause, they terminate in both ways. In either case, however, they form a closed system of tubes, independent

markable for its enormous size, in proportion to that of the kidney, for its origin from the aorta being at a right angle, and for its shortness. There are sometimes two or three renal arteries, and two are not unfrequently found twisted spirally around each other.

When the kidney is situated in the iliac fossa or in the pelvis, the renal artery or arteries generally arise from the common iliac.

The *renal vein* is as large in proportion as the artery, and passes in front of it into the vena cava.

The *lymphatic vessels* are but little known.

The *nerves* are very numerous, and are derived from the solar plexus; besides which, the lesser splanchnic nerve is distributed directly to the kidney.

The spermatic nervous plexus is formed by branches from the renal plexus, and this may explain the close sympathy between the testicle and the kidney. The great number of ganglionic nerves distributed to the kidney may account for the peculiar character of the pain experienced in this organ.

Injection of the renal vessels. A very coarse injection thrown into the artery will return by the veins. One thrown into the vein will return by the ureter, and not by the artery.* Having filled the artery with red injection, the vein with blue, and the ureter with yellow, I observed the following facts: —

The renal artery divides into several branches within the sinus, where it is surrounded with fat; these branches pass between the calyces, and then between the cones of the tubular substance, proceeding as far as the commencement of the cortical substance, without giving off any smaller branches: at that point, however, they divide and subdivide so as to form a vascular network, the meshes of which are quadrilateral, and of different sizes, inscribed within each other. The largest of these meshes embrace the entire base of each pyramid; the smaller pass in different directions through the substance of the bases.

In order to obtain a good view of this arrangement, it is necessary to divide an injected kidney along its convex border, and scrape away the tubular substance, which is so soft as to be easily removed. We shall then perceive that the arterial and venous network, corresponding to the base of each cone, is surrounded by a very thick fibrous sheath, apparently prolonged from the fibrous coat, which passes into the hilus. All the tubular substance being thus removed, the remaining cortical portion of the kidney presents the appearance of a series of perfectly distinct alveoli, each of which corresponds to a cone of the tubular substance. A very beautiful preparation may thus be made.

It remains for us to inquire how the arteries terminate. A number of vessels proceed from the convexity of the vascular network above described, traverse the cortical substance, become twisted like tendrils of the vine, and appear to terminate in small red masses, regularly arranged along the convoluted tubes of Ferrein. These small red masses are formed by the penetration of the injection into the cavity of each granule, as may be seen by examining a section of the kidney with a lens.† If both the artery and the vein be injected in the same kidney (and it is of importance that the vein should be injected before the artery, in order to prevent a mixture of the two injections), we shall see that the matter injected by the vein circumscribes that injected by the artery.

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of the bloodvessels, which merely ramify on their parietes. They are lined with a mucous membrane, continuous with that on the papillæ, and having a columnar epithelium.

The *acini* of Malpighi, or *granules* of M. Cruveilhier (*c''*), are not of a glandular nature; they consist entirely of minute convoluted arteries, which terminate in the veins, but have no direct communication, as was formerly supposed, with the uriniferous tubes; they are called the *glomeruli*.]

* [This is the result of rupture.]

† See note, *suprà*.

Almost all the vessels are destined for the cortical substance, the tubular substance scarcely receiving any branches * : the vessels of any one lobule do not communicate with those of the adjacent lobules.

Injection thrown into the ureter does not enter the uriniferous ducts, or at least very incompletely.

Developement. The surface of the kidney in the fœtus, as in the lower animals, is furrowed and lobulated. Each lobule is formed by the medullary substance, covered by a layer of the cortical substance. After birth the furrows are effaced, and the surface of the kidney becomes plane and smooth.

This change takes place during the first three years after birth; nevertheless the lobular arrangement not unfrequently continues for nine or ten years, and even during the whole period of life. When the kidney is the seat of disease, and more particularly when it is distended from an accumulation of urine within the calyces and pelvis, the lobular arrangement re-appears. Each lobule is then converted into a pouch, which is perfectly distinct from those in contact with it. The kidney is proportionally larger in the fœtus than in the adult.

Functions. The kidneys are the secreting organs of the urine. The urine is secreted by the cortical substance, and as it were filtered by the tubular substance; for perfectly formed urine is found in the former situation. The mechanism of this is not better known than that of other secretions; its rapidity is explained by the great quantity of blood received by the kidneys.

The Calyces, Pelvis, and Ureter.

Dissection. Remove the fat from the sinus, and study the arrangement of the pelvis and calyces externally. Divide the kidney from the convex border towards the hilus.

The *calyces* (*c c c'*, *fig.* 179.) are funnels (*infundibula*), or rather small membranous cylinders, embracing the bases of the papillæ by one of their extremities, almost in the same manner as the corolla of a flower embraces the stamina and pistil, and uniting at their other extremity with the adjacent calyces to form the pelvis of the kidney. They vary in number like the papillæ, or even more so, for two or three papillæ frequently open into the same calyx. Whatever their number may be, they generally unite into three trunks, a superior, a middle, and an inferior, which correspond to the three groups of lobules, into which the kidney may be divided. These three trunks unite to form the pelvis. The external surface of the calyces is in relation with a great quantity of fat, and with the divisions of the renal artery and vein.

The *pelvis* (*p*) is a small membranous pouch, situated behind the renal artery and vein, opposite the deep notch in the posterior border of the hilus, so that when seen from behind, it projects completely beyond that fissure. It is elongated from above downwards, and flattened from before backwards, and may become greatly dilated from retention of the urine, or from renal calculi: almost immediately after its commencement it becomes smaller, and takes the name of the *ureter*. In certain cases it would appear that there is no pelvis, and that the ureter succeeds immediately to the two or three trunks formed by the union of the calyces. The pelvis is therefore nothing more than the expanded or infundibuliform commencement of the ureter.

The *ureter* (οὐρὸν, urine; *u*, *figs.* 179. 181. 199.) is the excretory duct of the kidney, and extends obliquely from the pelvis of that organ to the inferior fundus (*bas fond*) of the bladder. It is generally single on each side, but

* [The vessels (*c*, *fig.* 180.) of the tubular portion run parallel with the tubuli from the cortical substance to the papillæ; they were mistaken by Ruysch for the tubuli themselves, which were, therefore, supposed by him to communicate with the arteries in the glomeruli.]

sometimes double, and that under two very different circumstances; for example, where the two kidneys are united into one, a double ureter is almost invariably found; and, secondly, when, there being two kidneys, one of them is divided into two very distinct portions. In the latter case the two ureters are often united into one, after a course of a few inches. There is then no pelvis properly so called, and the two ureters may be regarded as the prolongation of the two trunks of the calyces, which remain separate longer than usual.

The ureter is a cylindrical tube having whitish, thin, and extensible parietes, and varying in size from that of a crow's to that of a goose's quill. The most contracted portion of the canal is that situated in the substance of the parietes of the bladder. Occasionally it presents at various parts of its extent some circumscribed dilatations, which seem to indicate that the course of the urine had been for a time arrested. This canal is liable to extreme dilatation when any obstacle occurs to the passage of the urine: I have seen it as large as the small intestine.

Each ureter is *directed* obliquely downwards and inwards, as far as the side of the base of the sacrum: from this point (*fig.* 181.) it passes downwards, forwards, and then inwards (*u*, *fig.* 186.), to the lateral part of the inferior fundus (*a*) of the bladder, where it enters between the muscular and mucous coats, and passes obliquely for about ten lines within the substance of that organ, to one of the posterior angles of the trigone, at which point it opens by an orifice narrower than the canal itself, and having the form of a parabolic curve with its concavity directed inwards.

Relations. In proceeding from the pelvis of the kidney to the base of the sacrum, the ureter passes along the anterior margin of the psoas, and is covered by the peritoneum and by the spermatic vessels, which cross it very obliquely. The *right* ureter is in relation with the vena cava inferior, being situated on its outer side. Opposite the base of the sacrum, each ureter crosses the common iliac, and then the external iliac artery and vein of its own side. In the pelvis, the ureter is applied to the parietes of that cavity, is covered by the peritoneum. and crosses in succession the umbilical artery, or the cord by which it is replaced, the obturator vessels, the vas deferens (*t*, *fig.* 181.) in the male *, and the upper and lateral part of the vagina in the female. That portion of it which is contained within the substance of the walls of the bladder corresponds indirectly with the neck of the uterus; and this important relation explains why carcinoma of the neck of the womb is so frequently accompanied with retention of urine. I have also observed that the ureters of all females who have died after delivery, or during the last months of pregnancy, are remarkably dilated.

Internal surface. The internal surface of the calyces, pelvis, and ureters is white, smooth, and has longitudinal folds, which are effaced by distension. There are no valves, either at the opening of the calyces into the pelvis, or of the pelvis into the ureter, or in any part of that canal.

Structure. The calyces, the pelvis, and the ureter have all the same structure: they are formed by two membranes; an *internal membrane*, continuous with the vesical mucous membrane, very thin, and even having the appearance of a serous membrane; it is reflected from the calyces upon the papillæ, and is prolonged into the uriniferous tubes: an *external membrane*, which is very thick, and supposed to be a continuation of the external coat of the kidney, and therefore to be fibrous. Others regard it as muscular †; I believe that it is formed of a tissue analogous to the dartos. Some arteries and veins, probably also some lymphatics and nerves, are distributed upon the calyces, the pelvis, and the ureters, but do not require any special description.

* Passing to its *outer* side.

† [In some quadrupeds the ureter distinctly contracts on applying a stimulus.]

The Bladder.

The *bladder* (*h*, *fig.* 181.) is a musculo-membranous sac, which serves as a reservoir for the urine.

It is *situated* in the cavity of the pelvis, upon the median line, behind the pubes (*b*), and is retained in that position by the peritoneum (*u*), which only partially covers it, and by the *urachus*, a sort of ligament connecting it with the umbilicus. These means of attachment are in accordance with the great enlargement of which the organ is capable; but they cannot prevent certain partial displacements, known as *herniæ of the bladder*. When collapsed, it is completely protected from external injury; but when filled, it passes above the osseous girdle in which it is contained, and enters the dilatable cavity of the abdomen, where it can be distended to the utmost without inconvenience.

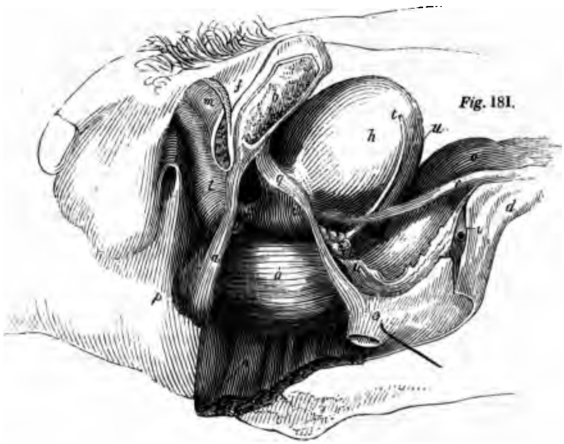


Fig. 181.

Number. The bladder is always single; the examples of *double* bladder which have been recorded, are cases of protrusion of the mucous membrane through the separated muscular fibres. But, whatever may be the size of these accidental bladders (and I have seen them twice as large as the true bladder to which they were attached), they may always be distinguished by their having no muscular coat. The cases of deficiency of the bladder are generally examples of that species of malformation, in which the viscus is open anteriorly, and is everted, so as to resemble a fungous mass.

Dimensions. The bladder is the largest of all the reservoirs of secretion, but its capacity varies, from a number of circumstances; from *habit* — in persons who are accustomed to retain their urine for a considerable period the bladder is more capacious than in those who immediately attend to the desire to pass urine; from *sex* — thus in the female the bladder is generally larger than in the male, because she is more influenced by the customs of society; from *age* — the bladder appears to be relatively larger before than after birth; from *disease* — in consequence of which it presents every variety betweeen a morbid state of contraction in which, from the contact of its parietes, it scarcely permits the accumulation of a spoonful of urine, and an extreme state of dilatation in which it can hold several pints of that fluid.

Direction. The direction of the bladder is determined by that of the anterior wall of the pelvis, so that its axis is oblique from above downwards and backwards. On account of this obliquity, a slight inclination of the trunk forwards makes the neck of the bladder the most dependent part of the organ. The obliquity becomes still greater when the distended bladder has escaped from the

pelvis, and entered the cavity of the abdomen: its axis then exactly corresponds with that of the brim of the pelvis; *i. e.* it is directed from the umbilicus to the lower part of the curvature of the sacrum. It has been said since the time of Celsus, that the upper part of the bladder is a little inclined to the left side, but I have not observed this.

Shape. The bladder is ovoid, the great end being directed downwards, and the smaller upwards. Its shape differs according to age and sex, and in different individuals. The sexual differences are not congenital; they seem to result from the pressure to which the female bladder is subjected during pregnancy; but the transverse enlargement and the vertical shortening of the bladder in a female who has borne children are not so well marked as is generally said.

Relations. In determining these, the bladder is divided into the *fundus*, which is the highest and the narrowest part; the *body*, or middle portion, and the *base*, which is the lowest and the broadest portion. It has, moreover, like all hollow organs, an external and an internal surface.

The *external surface* of the bladder is convex, and presents six regions for our consideration; the relations of which we shall now study, both in the collapsed and distended condition of the viscus. The *anterior region*, not covered by the peritoneum, is in relation with the symphysis and bodies of the ossa pubis, and with the internal obturator muscles, with which parts it is connected by a very loose serous cellular tissue, in stout persons more or less loaded with fat. Some fibrous bundles pass from the lower part of this region, and are attached to the sides of the symphysis; they are called the *anterior ligaments of the bladder*, and are traversed by numerous veins; they are a dependence of the superior pelvic aponeurosis (*q*, *fig.* 181.). (Vide APONEUROLOGY.) In the female, on account of the absence of the prostate, the anterior region of the bladder passes below the symphysis, and advantage may be taken of this circumstance in the extraction of calculi. When the bladder is full, its anterior region corresponds immediately with the parietes of the abdomen, and sometimes rises as high as the umbilicus. The practical conclusions to be derived from these relations refer to the examination of the bladder in the hypogastrium, to puncture of this organ in the same situation, to the high operation for stone, to the operation of dividing the symphysis, and lastly, to ruptures of the bladder in consequence of fracture of the pubes.*

The *posterior region* of the bladder is covered by the peritoneum (*u*) throughout the whole of its extent; in the male it corresponds with the rectum (*o*), and in the female with the uterus. Some convolutions of the small intestine almost always intervene between the bladder and those parts.

The *lateral regions* are also covered by the peritoneum; and passing upon each of them are found the umbilical artery in the fœtus, and subsequently the ligament by which it is replaced, and also the vas deferens (*t*) in the male. When the bladder is perfectly contracted, there is some distance between it and that vessel and duct on either side.

The relations of the *lower region* or *base* of the bladder, which are all very important, differ in the two sexes.

In the *male* it corresponds to the rectum, from which it is separated on either side in front by the vesicula seminalis (*s*) and the vas deferens. (*t*) The only part in direct relation with the rectum is therefore the triangular space (*fig.* 186.) comprised between the vesiculæ (*s s'*) and the vasa deferentia (*l l'*) of the two sides. It is of importance to remark, that the peritoneum, where it is reflected from the rectum upon the posterior region of the bladder, forms a more or less deep cul-de-sac in the middle, and two small folds on the sides, which have been improperly named the *posterior ligaments of the bladder*. When the bladder is much contracted, the peritoneum covers the whole of the space between the vesiculæ and the vasa deferentia; so that, properly speaking, there is

* It has even been proposed to puncture the bladder through the symphysis, by means of a flattened trocar; but the difficulty of coming exactly upon the symphysis will probably prevent the execution of this plan.

no immediate relation between that organ and the rectum. On the other hand, when it is distended, it becomes much enlarged posteriorly, and has much more extensive relations with the rectum.* It is important, also, to remark, that the peritoneum is very loosely united to the base of the bladder, so that they can be easily separated whenever it is desirable to reach the bladder from the rectum. On each side of the rectum the base of the bladder corresponds with the cellular tissue of the pelvis. The superior pelvic fascia and the levatores ani are attached to and embrace the sides of the base.

In the *female* the base of the bladder corresponds not only with the vagina, but with the lower half of the neck of the uterus; it adheres very intimately to the former, but loosely to the latter.

As practical consequences of these relations, I would point out the following: — In the *male* the occurrence of recto-vesical fistulæ, the possibility of exploring the bladder by the rectum, and of operating upon it in the same situation. In the *female* the capability of examining the bladder by the vagina, of puncturing it, and of performing lithotomy through the same part; the occurrence of vesico-vaginal fistulæ, and the frequency with which carcinoma of the bladder follows the same affection of the cervix uteri.

Summit, or fundus. This part of the bladder is directed forwards and upwards, and is covered by peritoneum. The *urachus* is a sort of cord, having a muscular appearance, and stretching from the summit of the bladder to the umbilicus, into which it appears to enter. This cord adheres tolerably firmly to the peritoneum †, which forms a falciform fold over it, and may be drawn down with it when it is displaced. In a case of hypertrophy of the bladder, I found the cord itself hypertrophied, and continuous with the longitudinal muscular fibres of the bladder, almost in the same way as the round ligament of the uterus with the fibres of that organ. The urachus is merely the vestige of a canal which exists in the fœtus of quadrupeds, and, according to several authors, in the human fœtus also.

There have been many discussions upon this subject, some stating that the cord is hollow, others that it is solid. I have always found it solid, both in the adult and in the fœtus. In one case I found a small concretion in it, which I regret not having submitted to chemical analysis. It is very common to find the urachus large at its origin, and becoming narrower after a course of two or three inches, and then blending with the cord, which takes the place of the left umbilical artery; at other times it expands into cellular tissue, and the filaments resulting from its division proceed, some to the umbilicus, and others to the cords which represent the obliterated umbilical arteries.

In the erect posture, the weight of the intestines presses on the summit of the bladder, which is thus pushed downwards; and hence the necessity for placing the patient, during certain operations, especially that of lithotrity, in the horizontal position, or even on an inclined plane, so arranged that the pelvis is more elevated than the shoulders.

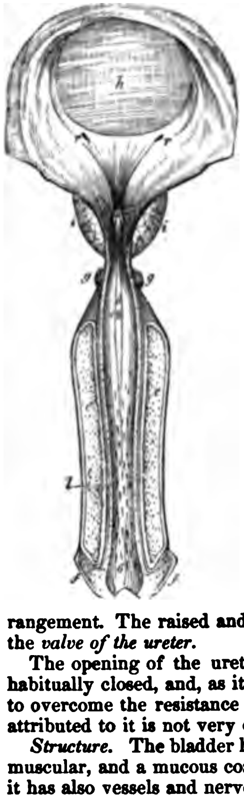
The *internal surface* of the bladder is covered by a mucous membrane, like all cavities which communicate with the exterior; and is remarkable for certain folds or wrinkles, which are effaced by distension, and for the reticular ridges formed by the fasciculi of its muscular coat; these are sometimes very highly developed, and, in certain cases, are so large, that they form pillars, which project into the interior of the bladder. The mucous membrane not unfrequently becomes insinuated between these columns, so as to form cells, or what is termed sacculated bladder. The base of the bladder presents three

* The varieties in the depth of the cul-de-sac formed by the reflected peritoneum, pointed out by modern surgeons, appear to me to be explicable by the difference in size of the bladders examined. The arrangement of the peritoneum seems to me to be exactly the same in all subjects.

† It would appear, from a fact which I have observed, that the bladder cannot be dragged into either internal abdominal ring, excepting after the urachus; this being itself drawn down by the peritoneum, with which it is closely united.

openings, viz. the orifices of the two ureters (*r r*, *fig.* 182.), and the opening into the urethra. These three openings occupy the angles of an equilateral triangle (" collicula ab ureteribus ad urethram producta," *Haller*), the surface of which is smooth and white, and is always devoid of wrinkles or columns. This is the *trigone* of the bladder, or *trigone of Lieutaud*, which has been supposed to possess a peculiar degree of sensibility. The posterior border (*r r*) of this trigone is more or less prominent in different individuals, and is formed by a line stretching between the orifices of the two ureters; this prominence is prolonged outwards on each side by the portion of the ureter which lies in the parietes of the bladder. It has been stated incorrectly, that the trigone is formed by the projection of the prostate, for it exists in females as well as in males, though it is less prominent in the former. All that part of the base of the bladder which is behind the trigone is generally called the *bas fond*, or *inferior fundus*.*

Fig. 182.



Most anatomists follow Lieutaud in describing, under the name of *uvula vesicæ*, a tubercle which arises from the lower part of the orifice of the urethra, and partially fills up that opening; but it exists only in cases of disease, being the result of hypertrophy of the middle portion of the prostate, described by Home as the middle lobe.

The orifices of the ureters are so constructed as to permit the easy passage of the urine into the bladder, but completely to oppose its reflux. Their long oblique course beneath the mucous membrane before opening into the bladder explains this arrangement. The raised and reflected portion of the membrane might be called the *valve of the ureter*.

The opening of the urethra, which is also called the *neck of the bladder*, is habitually closed, and, as it were, corrugated. Some force is required in order to overcome the resistance offered by it; the crescentic form which has been attributed to it is not very evident.

Structure. The bladder has three coats — a peritoneal, which is incomplete, a muscular, and a mucous coat; these are connected by layers of cellular tissue: it has also vessels and nerves.

The *peritoneal coat* covers the posterior and lateral regions, and the inferior fundus of the bladder. The anterior region and that part of the base which is in front of the inferior fundus are not covered by it. It is united to the muscular coat by very loose cellular tissue.

The *muscular coat* is formed of interlacing fibres, the direction of which it is, at first sight, very difficult to determine.† This coat is very thin, and does not form a continuous layer in enlarged bladders; but in small and contracted bladders it is continuous, and consists of several layers, and may even acquire a thickness of eight or ten lines from hypertrophy. It is then very easy to determine the direction of the fleshy fibres which seem to form a number of layers. The external layer consists of longitudinal fibres, all of which proceed from the neck of the bladder, and expand over the whole surface of the

* It is not uncommon to find the bladder forming behind the trigone a deep cul-de-sac, which I have seen insinuated between that part and the rectum.

† [These fibres belong to the involuntary class, the microscopic characters of which are described in the note, p. 426.]

organ; the next layer is formed of circular fibres, some of which are irregularly interlaced, while the others are parallel. The regular circular fibres are most numerous opposite the inferior fundus of the bladder, and are continuous with the annular fibres of the neck.

The irregular circular fibres are most common in the posterior region of the organ. In the situation of the trigone the muscular layer consists of transverse parallel fibres, placed near each other, and forming a perfectly regular plane. The transverse thick bundle stretching between the orifices of the ureters has been regarded by Sir C. Bell as the muscle of the ureters. Its contraction, by enlarging their orifices, will facilitate the entrance of the urine into the bladder.

The term *sphincter of the bladder* is applied to a muscular ring, which is continuous with the circular fibres of the body of the bladder, and is situated at the opening of the urethra. The vagueness and disagreement in the descriptions of this sphincter sufficiently prove that no very distinct structure of the kind exists at the neck of the bladder. Winslow describes some fibres arising from the ossa pubis, and embracing the sides of the vesical orifice, as the sphincter muscle, but they evidently belong to the levator ani. It is certain, however, that in the neck of the bladder there is a thin external layer of longitudinal muscular fibres, and also a deep and very thick layer formed of circular fibres; both layers seem to be continued into the prostatic portion of the urethra.

The *mucous coat* is extremely thin *, of a whitish colour, and presents some small papillæ. It is so difficult to demonstrate its follicles, that their existence has been denied: but, with a little attention, they may always be found in the neighbourhood of the neck of the bladder, and upon the trigone. I have seen them in all parts of the bladder, under the form of vesicles, in certain cases of disease. The mucous membrane is moulded upon all the ridges of the muscular coat: it sometimes dips between the muscular bundles, and forms cells, in which calculi are often lodged. Bladders of this kind are called *sacculated;* and moreover are almost always *fasciculated, i. e.* the muscular fibres are so highly developed, as to raise up the mucous membrane into ridges. The cellular tissue uniting the muscular and the mucous coats is tolerably loose, serous, and extremely delicate.

Vessels and nerves. The *vesical arteries* arise either directly from the hypogastrics, or from their branches. They are variable in number. The *veins* form a very remarkable plexus around the neck of the bladder, which is prolonged upon the sides of the inferior fundus, and terminates in the hypogastric veins. The *lymphatic vessels* are, for the most part, situated between the muscular and the peritoneal coats, and terminate in the hypogastric lymphatic glands. The *nerves* are derived from the hypogastric plexus, which is composed both of ganglionic and spinal nerves; and hence the bladder is partly subject to and partly beyond the influence of the will.

Developement. The bladder of the fœtus is remarkable for the predominance of its vertical over its transverse diameters, the latter being very short. This fact, added to the imperfect developement of the pelvis, explains why the entire bladder projects above the brim of the pelvis at this period of life. The inferior fundus does not exist. The summit is gradually continued into the urachus, which is then much larger than at subsequent periods, and of which the bladder appears to be merely an expansion. According to some authors, the bladder is relatively larger, and, according to others, smaller before than after birth.

In the early periods of infancy the bladder retains the characters which it had in the fœtus, and many important surgical inferences may, therefore, be drawn from its more extensive relations with the abdominal parietes. In proportion as the pelvis is developed, and, also, perhaps, in proportion as the

* [This and all the other portions of the genito-urinary mucous membrane have an epithelium, which approaches to the columnar in character.]

frequently accumulated urine dilates the bladder in its transverse and antero-posterior diameters, this organ sinks into the pelvic cavity, and when completely developed, presents the characters already assigned to it.

The *urachus*, which, we have seen, is converted into a muscular cord in the adult, and is sometimes lost before reaching the umbilicus, is much more developed in the fœtus: it may then be traced as far as the umbilicus, and even, according to some anatomists, through the whole extent of the umbilical cord. Analogy and some observations upon the human subject would seem to show that the urachus is hollow in the fœtus. In the lower animals the cavity of the urachus may be traced into a bag called the *allantois*, which is situated between the membranes of the ovum; and it is stated by several authors, that they have caused mercury, injected into the bladder, to pass some distance (half an inch, one inch, or one inch and a half) into the urachus, and even for a greater or less extent into the umbilical cord.

Moreover, in new-born infants, and even in adults, the urine has been seen to escape through the umbilicus; but in these cases the urethra is always obliterated. I have already said that I have met with a calculous concretion within the substance of the urachus, and I find that Haller and Harder have made a similar observation (*arenulæ in uracho visæ*). M. Boyer (*Traité d'Anatomie*, p. 477., SPLANCHNOLOGIE) says, that he has dissected the bladder of a man, twenty-six years of age, whose urachus formed a canal an inch and a half long, and contained twelve urinary calculi, as large as millet seeds; one of them was larger, and resembled a grain of barley. He convinced himself that the canal which contained these calculi was not formed by a prolongation of the internal membrane of the bladder through the other coats. On the other hand, a number of observers (myself among them) have found the urachus solid in the fœtus. New facts are, therefore, necessary to settle this anatomical question; although it is very probable that the urachus of the human subject is of the same nature as that of animals, but becomes obliterated at a much earlier period.

Functions. The bladder is intended as a reservoir for the urine, and is also the principal agent in its expulsion. The urine constantly trickles drop by drop into the bladder, but cannot flow back by the ureters on account of the mechanism already described. When the bladder is distended it occasions a desire to evacuate its contents, and the urine is then expelled by the combined action of the bladder itself and the abdominal muscles. I have said that the bladder is the chief agent in this expulsion, for in cases of retention of urine from paralysis, or excessive distension of the bladder, the most powerful contractions of the abdominal muscles are not sufficient to expel it.

THE SUPRARENAL CAPSULES.

The *suprarenal capsules* (*c c*, *fig.* 199.) are organs whose use is unknown; they are situated near the upper end of the kidneys, and, like them, are outside the peritoneum.

The proximity of the kidneys and suprarenal capsules has led to the supposition, that there is some mutual relation between their functions; and hence they are generally described together, though not on perfectly just grounds.* The name *renes succenturiati* (*Casserius*) is sufficient evidence of the relation which has been supposed to exist between these organs. Nevertheless, this connection of situation, which constitutes the most important and characteristic feature in the history of the suprarenal capsules is not constant; and in the numerous cases in which the kidneys occupy some unusual position, the suprarenal capsules do not accompany those organs in their displacement. Thus, when the kidneys are situated higher than usual, the capsules are placed on their inner side, and correspond with the renal fissure;

* Eustachius, who first described them, called them *glandulæ quæ renibus incumbunt*.

when the kidneys occupy the pelvic region, the capsules undergo not the slightest change in their position, and no longer have any connection with them.

Number. There are two suprarenal capsules: it is said that two have been found on each side.

Size. They vary much in size in different individuals: sometimes they are so small that they can scarcely be distinguished from the fat by which the kidney is surrounded; at other times they are very large. In a case where the two kidneys were very small, I found the suprarenal capsules much larger than usual. It has been said that they are larger in the negro than in the Caucasian race. I have examined two negroes, and did not find them unusually large. In the fœtus they are proportionally larger than in the adult. I have found them very large in several females far advanced in years.

The two capsules are not of the same size. Eustachius affirms that the right is larger than the left; but I have generally found the reverse. Their weight is about one drachm.

Form. I shall follow the example of M. Boyer, in comparing these suprarenal capsules to a helmet, flattened on its anterior and posterior surfaces, and embracing the upper end of the kidney by a narrow and concave surface. The relations of its *anterior surface* are different on the right and the left side.

On the *right side* it is in relation with the liver, to which it adheres by a tolerably dense cellular tissue, so that the capsule is always removed in connection with that organ. This relation between the liver and the capsule is much more constant and intimate than that between the capsule and the kidney. A small depression, already described as existing on the lower surface of the liver, to the right of the vena cava ascendens, is intended for the reception of the capsule.

On the *left side* the capsule is in immediate relation with the pancreas, and is indirectly connected with the spleen and the great end of the stomach.

The *posterior surface* is in contact with the highest part of the pillars of the diaphragm, opposite the tenth dorsal vertebra. The great splanchnic nerves and the semilunar ganglia are situated behind, and on the inner side of the capsules, to which they send off so many branches, that Duvernoy regarded these organs as the ganglia of the renal nerves.

Their convex, thin, and slightly sinuous border is directed inwards and upwards. Their concave border is thick, and almost always deeply grooved. The surface of the capsules is invested by a thin layer of fat, which it is extremely difficult to remove, on account of the numerous fibrous and vascular prolongations that pass into it from the capsule; certain furrows, either containing vessels or not, and varying in depth and extent, traverse the surface of this organ, especially in front.

Cavity. It is still doubtful whether the suprarenal capsules have a cavity in their interior, as their name would seem to indicate. It is certain that in the greater number of subjects, on dividing them in different directions, they are found to consist of two laminæ applied to each other, and united as by an adhesive substance, a sort of dark-coloured, false membrane; and that these laminæ are reflected inwards opposite the concave border, so as to form a projection like a cock's comb in the interior of the capsule. The colour of the external surface is yellowish, or rather mottled with large yellow and brown spots. The internal surface, or rather of the parts which are in contact, is chestnut brown, or bistre colour of different shades, so that I am induced to compare its appearance with that of an apoplectic cyst. It seems as if in this, as in the other case, blood had been effused, and then absorbed.

The internal surface is also rough, and as it were lacerated; a sort of yellowish, or chestnut-coloured pulp may be scraped off it. I have seen roundish, pulpy vegetations springing from several parts of this surface, sections of which presented a yellowish colour, mottled with brown.

The name of *atrabiliary capsules*, given to them by Bartholin, is undoubtedly derived from the deep brown colour of their internal surface. That anatomist regarded them as small pouches or capsules, and thought that they were the reservoirs of the blackish fluid (sanguis niger, *Bartholin*; succus atrabiliaris, atramentum glandulosum, *Lecat.*), to which the ancients gave the name of atrabilis.

Structure. The suprarenal capsules consist of two substances: one external or cortical, yellowish, and striated, which forms almost the whole thickness of the capsule; and an internal or central portion, presenting the appearance of a soft layer of a deep chestnut brown colour, and traversed by numerous vessels. The striated arrangement of the cortical layer, which is so easily seen in large animals, is frequently effaced in the human subject, where the capsule appears reduced to a thin yellowish lamella, folded back upon itself. The lobular character of the surface is only apparent, and depends upon the furrows formed in it for the vessels. The granular structure, admitted by most of the authors who have called these organs glands, has not been clearly demonstrated.

A fibrous *membrane*, analogous to the proper coat of the kidney, covers the suprarenal capsules.

The *capsular arteries* are very numerous and very large, in proportion to the size of the organ; they are divided into the *superior*, arising from the phrenic, the *middle*, proceeding directly from the aorta, and the *inferior*, furnished by the renal arteries. The *veins* are very large, and soon pass into the vena cava; the anterior furrow is chiefly intended for them. It has been supposed that they open directly into the cavity of the capsule, on account of the facility with which this latter may be distended by injecting air or any fluid into the veins. But it is probable that in such cases laceration has occurred. The veins of the right capsule enter the vena cava inferior directly; those of the left enter the renal vein of the same side. The *lymphatic vessels* are little known. The *veins* are very numerous; they are derived directly from the semilunar ganglia and solar plexus, and also from the renal plexus. It is in vain to search for the *excretory duct*, admitted by several anatomists; and described by some as entering the pelvis of the kidney, and by others as terminating in the testicle in the male, and in the ovary in the female.

Developement. The suprarenal capsules are relatively much larger in the fœtus than in the adult, and they are remarkable in this respect, that their size is inversely proportioned to that of the kidneys. They are distinct as early as the second month of intra-uterine life, and at that time exceed the kidney both in weight and size. This predominance continues during the whole of the third month; at the fourth, the kidneys and the suprarenal capsules are of equal size; at the sixth month, the capsules are not more than half as large as the kidneys; at birth, not more than one-third. The existence of a cavity is not more evident in the fœtus than in the adult.

In the aged, the suprarenal capsules are sometimes very large, and their colour is always yellow at this period of life.

Uses. The uses of the suprarenal capsules are unknown; we are even ignorant whether they should be classed among the glands. The great number of vessels with which they are supplied, and the numerous nerves distributed upon them, sufficiently prove that something more than mere nutritive changes must occur within these organs. Their pathological anatomy, which still remains to be investigated, may perhaps throw some light upon this obscure point of physiology.

THE GENERATIVE ORGANS.

THE generative apparatus presents this remarkable peculiarity, that the organs of which it is composed are divided between two individuals of the same species; and from this division results the difference of sex.

The male sex is chiefly characterised by the faculty of producing a fecundating fluid, the *spermatic fluid*, or *semen*. The female sex is characterised by the faculty of producing certain *ovules*, which become fitted for the reproduction of an individual of the same species, as soon as they have been submitted to the fecundating influence of the fluid secreted by the male. The female sex is also characterised, in the human species, and in all mammalia, by the possession of a gland (the *mamma*), which is intended to provide nutriment for the newly born creature.

The genital organs occupy the lower extremity of the trunk; they are situated in contact with the termination of the digestive canal on the one hand, and of the urinary organs on the other, with the latter of which they have the most intimate connections, especially in the male.

THE GENERATIVE ORGANS OF THE MALE.

The Testicles and their coverings.—The Epididymis, the Vasa Deferentia, and Vesiculæ Seminales.—The Penis.—The Urethra.—The Prostate and Cowper's Glands.

The *genital organs of the male* consist of a secreting and an excretory apparatus, composed of the following parts:—two glands, called the *testicles*; two provisional excretory canals, the *vasa deferentia*; two reservoirs for the spermatic fluid during the longer or shorter intervals between the periods of its expulsion, named the *vesiculæ seminales*; and certain ultimate excretory canals, the *ejaculatory ducts and the urethra*. To this latter canal is annexed an erectile structure, which enables it to assume the condition necessary for the ejection of the fecundating fluid; together, they form the *penis*. The *prostate gland* and *Cowper's glands* yield secretions, the use of which is connected with the generative functions: they may be regarded as appendages of the urethra.

THE TESTICLES AND THEIR COVERINGS.

The Coverings of the Testicle.

The coverings of the testicle consist of several layers; which, reckoning from without inwards, are the scrotum, the dartos, the tunica erythroides, the fibrous coat, and the tunica vaginalis. There is a sixth testicular covering, named the tunica albuginea; but, as it forms an integral part of the testis, we shall describe it with that organ.

The *scrotum* *, or cutaneous covering of the testicles, is a sort of pouch or bag common to both of those organs; the skin of which it is composed exhibits the following peculiarities.

It is of a browner colour than that of other parts of the body, so that in some individuals a layer of colouring matter, similar to that existing in the negro, may be demonstrated beneath it; like the skin of the penis and the eyelids, it is very thin, on account of the tenuity of its chorion; it is much larger

* From the Latin word *scrotum*, a sac, or purse of leather. The Greek term for the same part is ὄσχεον, and hence the word *oscheocele*, which serves to designate every tumour developed in the scrotum.

than is needed for containing the testicle; it is provided with scattered and obliquely inserted hairs, the follicles of which are large, and project upon the surface; and, lastly, its external aspect presents many varieties: thus, it becomes flaccid and elongated under the influence of warmth, and in old and enfeebled persons, while during youth, in the robust, and under the influence of cold, it becomes contracted, wrinkled, and closely applied to the testicle.

The scrotum is divided into two equal halves, by a sort of median line or ridge, called the raphé, from the Greek word ῥάπτω, to sew; because the two halves of the skin appear to be united at this part, as it were by a seam.

The object of the great extent of the skin of the scrotum is, perhaps, to enable it to cover the penis when in a state of erection.

The *dartos* is a reddish filamentous tissue, traversed by a great number of vessels, which can be easily seen through the skin of the scrotum. This tissue envelopes both testicles, and furnishes a prolongation interposed between them, and forming the *septum of the dartos.* Upon the sides, and opposite the spermatic cord, the dartos terminates abruptly, and is replaced by adipose cellular tissue. In front, it is continued around the penis; behind, it is prolonged upon the median line, by an angular extremity, as far as the sphincter ani.

It follows, therefore, that there is only a single dartos, within which are contained both testicles, a septum alone intervening between them. This separation in the middle line has led some to follow Ruysch, in describing a distinct dartos for each testicle. The dartos is closely united to the skin of the scrotum by its external surface, and it is very loosely connected by extremely delicate cellular tissue, with the subjacent coverings, upon which it glides with the greatest freedom.

With regard to its structure, the dartos at first sight presents some analogy to cellular tissue, but it differs from it essentially in its aspect; for in no situation does cellular tissue exhibit distinct reddish nodulated filaments, like those of the dartos. It is true that these filaments are irregularly interlaced, but the majority of them pass in a vertical direction; and when a single fibre is examined, we are struck with its analogy to muscular tissue.* It also differs in its vital properties: thus, the dartos possesses the property of active contractility, as is seen in the contraction of the scrotum, and the vermicular motions observed in persons exposed to cold, or under the influence of great dread, or of the venereal orgasm, and also in the much more evident contraction of the scrotum after an irritating injection has been thrown into the cavity of the tunica vaginalis.

It is, therefore, intermediate between cellular and muscular tissue, and might be called the *dartoid tissue.* It was for a long time supposed to be confined to the scrotum, but it is met with in many other parts, viz. the vagina, the substance of the nipple, and the parietes of the veins, of which it seems to me to form the external coat.

Some anatomists regard the dartos as nothing more than the remains of the *gubernaculum testis;* but, in the first place, the dartos is found in the fœtus, before the descent of the testicle; and in an adult, whose testicle had not escaped from the external abdominal ring, I satisfied myself that the gubernaculum and the dartos existed separately and independently of each other.†

The dartos has also been incorrectly regarded as a continuation of the *superficial fascia* (see APONEUROLOGY).

The tunica erythroides. This name (derived from the Greek word ἐρυθρὸς, red) is given to a thin membrane, formed by an expansion of the fibres of the

* [According to M. Jordan (*Müller's Archives*, 1834), the tissue of the dartos is composed of *uniform cylindrical* filaments, which resemble those of cellular tissue in diameter, but are larger than the varicose filaments of voluntary muscular fibre, and smaller than the involuntary muscular fibres, excepting those composing the iris. They resemble cellular tissue, and not muscle, in their chemical characters, and differ from the former only in presenting a reddish aspect, and in being arranged into longitudinal fasciculi, instead of interlacing in all directions.]

† The specimen from which this statement is taken has been presented to the anatomical society by M. Manec.

cremaster. It is very well marked in the young and vigorous, but becomes partially atrophied in the aged.*

We have already seen (vide *Obliquus internus abdominis*, MYOLOGY) that the cremaster is essentially formed of fibres arising directly from the groove of the crural arch, on the outer side of the inguinal canal. The loops formed by the lower portions of the obliquus internus and transversalis are, where they exist, completely distinct from it. The cremaster and the tunica erythroides, which is an expansion of it, are the agents of the sudden upward movement of the testicle, which is very distinct from the slow vermicular motion resulting from the action of the dartos. In a patient whose urethra was extremely irritable, I found that the introduction of a bougie was followed by a sudden and long-continued elevation of the testicles, with a separation of their lower ends. This movement was entirely independent of the dartos and scrotum, which remained flaccid and pendent in front of the thighs.

When the cremaster reaches the testicles, it expands into a number of fasciculi, distributed over the surface of the fibrous coat, and inserted, in the lower animals, by well marked tendinous fibres, which, however, I have never been able to discover in man. In hydrocele, these fibrous bundles resemble small cords, which, as Sir A. Cooper judiciously remarks, may be mistaken for veins.

The common fibrous coat. This membrane is very distinct from the tunica vaginalis, which lines its inner surface; it forms a common covering for the testicle and the spermatic cord; it is thin and transparent, narrow along the cord, and expanded below, so as to cover the testicle. At the inguinal ring it divides into two laminæ; one of which, almost always incomplete, is attached to the circumference of the ring, whilst the other seems to be prolonged within the canal, where it is, however, very difficult to follow it. Modern anatomists regard this fibrous tunic as a prolongation of the *fascia transversalis*, which would be dragged down with the testicle during its descent.

The tunica vaginalis, or serous coat. The *tunica vaginalis* is a shut sac, and presents two portions; one, *parietal* (*p*, *fig.* 183.), lining the fibrous coat, the other, *reflected* or *testicular* (*v*), which covers the testicle, without that organ being contained within the sac.

The intimate union of the serous and fibrous coats of the testicle affords an example of a fibro-serous membrane, analogous to the dura mater and the pericardium. As the reflection of the tunica vaginalis upon the testicle takes place at a variable height, it follows that a greater or less portion of the cord is covered by this coat.

The arrangement of the tunica vaginalis on one side of the epididymis differs from that on the other. On the *outer side* it immediately invests the epididymis, is then reflected from it, becoming applied to the part reflected from the opposite side of the epididymis, and forms a cul-de-sac, by which the middle of that body is completely separated from the upper border of the testicle. At the bottom of this cul-de-sac are some small openings, leading into a back cavity. It forms, therefore, a fold like the mesentery, at the middle of the epididymis, the two ends of which, however, are closely applied to the testicle. On the *inner side* it rises higher upon the cord than on the outer side, and is separated from the epididymis by the vas deferens and the spermatic vessels. It is easy to detach it from the fibrous coat, where it is reflected upon the testicle, but it adheres closely to the epididymis and to the tunica albuginea.

Its internal surface, free and smooth, exhales a serous fluid, the morbid accumulation of which constitutes the disease called *hydrocele*. In most animals the tunica vaginalis communicates with the peritoneum at all ages; but in man this communication exists normally, only during intra-uterine life. After birth the two cavities are perfectly distinct. If, from any cause, this separation is not completed, the tunica vaginalis may form either a hernial sac, containing

* The cremaster is extremely well developed in the stallion; in which animal it is easy to establish the distinction between this muscle and the lower fibres of the internal oblique, the loops of which do not exist in all subjects.

displaced intestines, or a cyst containing serous fluid effused from the abdomen. In the former case, the disease is called *congenital hernia*, in the latter, *congenital hydrocele*.

The Testicles.

The *testicles* (*testes*) are two glandular organs, intended to secrete the spermatic fluid. They are situated in the scrotum, at the sides of and below the penis, and are therefore exposed to external violence. They are supported by their coverings, and by the cord formed by the spermatic vessels, and are at a greater or less distance from the inguinal ring, according as the dartos and cremaster are in a state of relaxation or contraction.

The testicles are not situated at exactly the same height, the left descending a little lower than the right. This arrangement, which has not escaped the observation of painters and sculptors, assists in protecting them from injury by enabling them to glide one above the other when the thighs are closely approximated, and thus to avoid compression. Their situation is not the same at all periods of life. In the fœtus, they are contained within the abdominal cavity. Sometimes they remain permanently, or much longer than usual in that situation, which, in the natural state, is merely temporary.

Number. The varieties in the number of the testicles are most of them only apparent. Thus, for example, in almost all *monorchides* (persons having but one testis; from μόνος, single, and ὄρχις, a testicle), that testicle which is absent from the scrotum is situated in the abdomen. Nevertheless, I have had occasion to dissect an individual who had only one testicle; there was an atrophied vesicula seminalis on the side where the testicle was wanting; the vas deferens commenced at this vesicle, and was lost upon the side of the bladder. I was not able to examine the spermatic vessels. The examples of three, four, or five testicles are not well attested.* An epiploic, or fatty tumour, or a cyst, may have been mistaken for a testicle.

Size. The testicles vary in size in different individuals, and still more at different ages. At the period of puberty, the testicle, which up to that time had been as it were in a state of atrophy in comparison with the rest of the body, increases greatly in size. This atrophy, which is normal before puberty, may continue to a more advanced age. In a subject about twenty years of age, in which the penis and larynx were highly developed, I found the two testicles atrophied: they weighed less than a drachm; the epididymis, although it was atrophied, was larger than the body of the testicle.

The two testicles are not exactly of the same size; the left is generally larger than the right; but this difference is so slight and inconstant, that some anatomists have even thought that a slight predominance may be observed in the right.

The following are the average dimensions of the testicle:—length, two inches; breadth, one inch; thickness, eight lines.

Weight. According to Meckel, the weight of the testicle is four drachms; according to Sir Astley Cooper, one ounce.

Consistence. It is extremely important, especially in a practical point of view, to judge of the natural consistence of the testicle. The character of this consistence is determined less by the proper substance of the testicle than by the degree of tension of its immediate covering; and in this respect the consistence of the testicle very much resembles that of the eye. In the aged, the seminiferous ducts being empty, the testicle becomes soft, and, as it were, atrophied. It would be still less consistent, if it were not for the serous fluid with which the cellular tissue between these ducts becomes infiltrated.

Figure, direction, and relations. The testicle is oval, but flattened at the sides. This form, added to the polished and slippery character of its surface,

* I have been consulted concerning a child, who appeared to me to have two testicles upon one side, each of which was as large as that of the opposite side; but it is impossible to decide with certainty upon such a matter until dissection has shown the true nature of pretended supernumerary testicles. Nevertheless, the kind of pain felt upon pressing the body imagined to be a testicle may afford tolerably satisfactory indications during life.

enables it easily to avoid compression. The long diameter or axis of the testicle is *directed* obliquely downwards and backwards; its *lateral surfaces* and its *lower border** are convex, free, smooth, and constantly lubricated by the serosity of the tunica vaginalis. The *upper* border is straight; it is directed backwards, is embraced by the epididymis, which surmounts it like the crest of a helmet, and is covered by the tunica vaginalis in a small portion only of its extent. The spermatic vessels enter at the inner part of this border, and behind the head of the epididymis. The *anterior extremity* of the oval is the larger, and is directed upwards and forwards; the *posterior extremity* is turned backwards and downwards. The white colour of the surface of the testicle is owing to its proper fibrous covering, which, on account of its whiteness, is called the *tunica albuginea.*

Structure. The constituent parts of the testicle are a fibrous membrane, a proper tissue, and certain vessels and nerves.

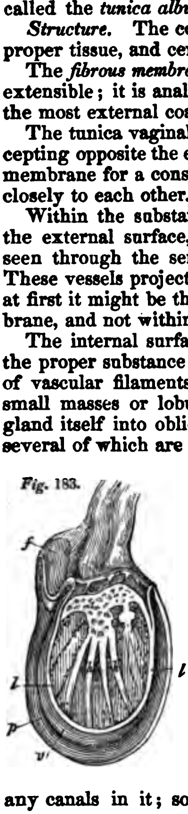
The *fibrous membrane, tunica propria sive albuginea,* is white, strong, and inextensible; it is analogous to the sclerotic coat of the eye, and, like it, forms the most external coat or shell of the organ which it covers.

The tunica vaginalis invests the outer surface of the tunica albuginea, excepting opposite the epididymis, where the fibrous coat is destitute of the serous membrane for a considerable extent. The serous and fibrous layers adhere closely to each other.

Within the substance of the tunica albuginea, but nearer the internal than the external surface, are a great number of tortuous vessels, which may be seen through the semitransparent fibrous layer by which they are covered. These vessels project on the internal surface of the tunica albuginea, so that at first it might be thought that they were simply in contact with the membrane, and not within its substance.†

The internal surface of the tunica albuginea is in immediate relation with the proper substance of the testicle, and is connected with it by a great number of vascular filaments, which traverse it in all directions, and divide it into small masses or lobules, and also by the extension of the substance of the gland itself into oblique culs-de-sac, or cells formed by the tunica albuginea, several of which are a line and a half or two lines deep. When the tunica albuginea is carefully removed, filaments of the glandular substance are seen escaping from these small cells, which are most numerous at the upper borders of the testicle. The strength of the vascular filaments which traverse the testicle, has led to the opinion that they are all enveloped by a fibrous sheath derived from the tunica albuginea, but I have never been satisfied of the existence of these sheaths.‡

Fig. 183.



At the upper border of the testicle, the tunica albuginea becomes remarkably thickened, and forms the *corpus Highmori,* or mediastinum testis (*Cooper*). In order to obtain a correct notion of this structure, it is necessary to make a vertical section of the testicle, at right angles with its long diameter: we then observe a nucleus (*i, fig.* 183.), or fibrous thickening of a triangular shape, perforated by bloodvessels, but do not at first sight discover any canals in it; so that we might be inclined to agree with Winslow (who

* [M. Cruveilhier differs from most other anatomists in applying the terms *upper* and *lower* to the opposite *borders* of the testicle, instead of *posterior* and *anterior;* on the contrary, he describes the two *extremities* of this organ as *anterior* and *posterior*, instead of *upper* and *lower*, as is usually the case.]

† The existence of numerous vessels within the substance of the tunica albuginea has led Sir Astley Cooper to describe two layers in it; — an external, which he compared to the dura mater, and an internal (the tunica vasculosa), which he likened to the pia mater. I cannot admit this analogy. The vessels contained in the tunica albuginea rather resemble the sinuses of the dura mater than the vascular network of the pia mater.

‡ See note, p. 560.

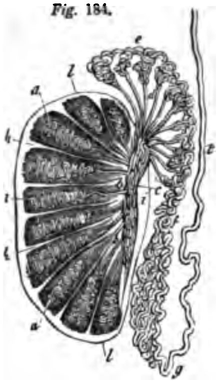
called it the nucleus of the testis) in denying that it contains any canals; or rather with Swammerdam, in regarding those canals that do exist in it, as destined exclusively for the arteries and veins.

If, after dividing the testicle along its convex border, we reflect the tunica albuginea, we shall see that near the upper border the filaments (*a a*, *fig.* 184.) which constitute the substance of the testicle enter (*b b*) numerous spaces existing in the tunica albuginea at this part, pass towards the thickening (*i*) of the upper border, traverse it (*c*) from its posterior to its anterior extremity, and then uniting together into a greater or less number of tubes, perforate (*d*) the tunica albuginea opposite the head of the epididymis (*e*).

The corpus Highmorianum, moreover, exists only in the anterior half of the upper border of the testicle (see *i*. *fig.* 184.). All the bloodvessels reach the testicle at this point, and having entered it there, divide into two sets; one of these is situated in the substance of the fibrous coat, so as to form its sinuses (the tunica vasculosa), and furnishes a multitude of vessels, which are given off from it in succession, and are distributed to the substance of the gland.* Among these vessels, I would particularly notice one tortuous artery which passes from before backwards along the upper border of the testicle. The other set of vessels perforate the corpus Highmorianum directly, and pass from the upper to the lower border of the testicle. The corpus Highmorianum then is a thickening of the tunica albuginea, which occupies the anterior half of the upper border of the testicle, and is perforated by the filaments composing the proper tissue of the testicle, and also by a great number of bloodvessels.

Proper tissue. The proper substance of the testicle resembles a soft yellowish pulp, grooved by a multitude of small tense and strong columns, which divide it into a great number of masses or *lobules* (*a a*, *fig.* 184.). These small columns are nothing more than the vessels given off from the tunica albuginea.† Each lobule represents a pyramid, the apex of which is directed towards the upper border of the gland, and the base towards its lower border. The lobules consist of a collection of extremely delicate filaments, folded a very great number of times upon themselves, so as to resemble the granules of glands, and have in fact been described as such by some anatomists.‡ These filaments are the *seminiferous tubes*, which were injected by Haller and Monro from the vas deferens. I have in vain attempted to perform the same experiment; the mercury never passed beyond the epididymis. It has been said that each lobule is formed by one or two tubuli, and the number of these tubes has been calculated at 300. Each tubulus is said to be 16 feet long, and $\frac{1}{200}$th of an inch in diameter. According to Monro's calculation there would be 5000 feet of tubuli seminiferi in the small space occupied by one testicle.

Fig. 184.



* [According to Sir Astley Cooper, many of the arterial vessels pass along the septa, extending from the inner surface of the tunica albuginea to the mediastinum, and then turn back and are distributed upon the lobes. The principal veins arise upon the larger ends of the lobes, pass up to the mediastinum, and perforate it.]

† [Sir Astley Cooper has described fibrous columns which extend from the inner surface of the tunica albuginea, and unite with similar prolongations given off from the mediastinum testis, and forming the sides of the cells described by M. Cruveilhier (p. 599.). From these columns lateral membranes proceed, so as to form septa between the larger masses of glandular structure, whilst other finer membranous extensions enclose the small lobes in separate pouches. The larger bloodvessels are supported by the columns, and the smaller ones ramify upon the membranous septa and pouches.]

‡ Riolanus described a fibrous thickening of the proper coat of the testicle. The description given by Highmore is very confused; he describes a body *obscurè aut omninò non cavum*, which *appears* to *perforate* the tunica albuginea, and to convey the semen to the epididymis: he has also represented as opening into this canal certain parallel vessels, which he considered to be an artery and a vein.

If we take hold of the substance of the testicle with a pair of pincers, and then draw it out slowly, we shall raise a number of apparently knotted filaments from the common mass; some of which will break immediately, whilst others may be drawn out to a foot, a foot and a half, or two feet, without breaking. It is particularly easy to pull out the filaments when the tissue of the testicle is very moist. The little knots disappear during this process, and the tubuli then assume the character of straight and almost transparent filaments.*

The proper tissue of the testicle adheres to the tunica albuginea by the blood-vessels only, excepting near the upper border of the testicle. In this situation, the tubuli are lodged in the cells or spaces, already described, in the substance of the tunica albuginea; they all pass towards the corpus Highmori, traverse it from behind forwards, and form within its substance what Haller described as the *rete vasculosum testis* (*c*, *figs.* 184, 185.), because he supposed that the seminiferous tubes in this situation communicated with each other. †

Lastly, the tubes composing the rete unite into an indeterminate number of efferent ducts (*d*), estimated at from ten to thirty, which perforate the tunica albuginea, opposite the head of the epididymis.

Vessels and nerves. The *testicular artery*, the principal division of the spermatic, divides before entering the testis into several branches, which pass into the tunica albuginea along the upper border of the gland, and are distributed, as I have already pointed out when speaking of the corpus Highmori. The *veins* are very numerous, are arranged in an analogous manner, and form the spermatic veins. The *lymphatics* are very numerous, and are divided into the superficial and deep.

The *nerves* are derived both from the ganglionic and the cerebro-spinal system. They have not been traced into the interior of the testicle, and yet the sensibility of that organ is sufficient evidence of their existence there.

The *serous cellular tissue*, by which the seminiferous ducts are united, is so delicate, that it can only be shown by the aid of a very favourable light.

The Epididymis.

The epididymis (*e f*, *figs.* 184, 185.) is the vermiform appendage which lies along the superior border of the testicle, like the crest upon a helmet. Its name is derived from its position (ἐπί, upon, δίδυμος, the testicle).

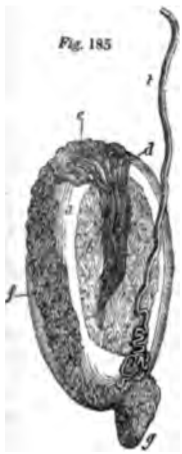
It is so situated that it does not precisely occupy the superior border of the testicle, but encroaches a little upon its outer face (see *fig.*182., a section of the right testis), so that when the tunica vaginalis is opened, and the inner side of the testicle examined, we cannot see the epididymis. It is closely connected with the testicle by its anterior extremity, which is remarkably enlarged, and is called the *head*, or *globus major* (*e*); its middle portion or body (*f*) is separated from the testis; and it again adheres by its posterior extremity, called the *tail*, or *globus minor* (*g*); which, after being prolonged as far as the posterior extremity of the testis, turns upwards, by being reflected upon itself, and gives origin to the vas deferens (*t*). It is flattened from above downwards, concave below, and slightly flexuous; its two extremities are covered by the tunica vaginalis only above and on the outside, but its body is completely enclosed by that membrane, which forms a fold for it like the mesentery. (See *Tunica Vaginalis.*)

* [The seminiferous tubes are of the same diameter throughout. According to Lauth, they most commonly terminate in loops, and by numerous anastomoses; in one instance only did he observe a free closed extremity. In some animals, Müller found the seminal tubes ending in free extremities; and the same mode of termination was frequently seen by Krause in the human testis. Like the uriniferous tubes, the tubuli seminiferi terminate, therefore, in two ways.]

† [Immediately before the tubuli pass into the corpus Highmori to form the rete, they become rather larger and straight, and are hence called the *tubuli recti* (*d d*, *fig.* 184.): the tubuli composing the rete are stated by Lauth to vary from seven to thirteen; they are tortuous, and, as supposed by Haller, anastomose.]

Structure. When the tunica vaginalis, which gives the epididymis a smooth appearance, is removed (as in *fig.* 185.), the latter resembles a cord, so twisted upon itself that it would appear impossible at first sight to disentangle it. This cord is hollow, as may be shown by injecting mercury or a coloured liquid into it through the vas deferens. The canal or duct which forms the epididymis is not unfrequently found distended with semen; and then we may ascertain by simple inspection, as well as by injecting it, that it is of a determinate size, and that its parietes are thin and semi-transparent.

Fig. 185



The epididymis is intimately connected with the body of the testicle by its *head* only; the other means of attachment between the two parts consisting exclusively of rather dense cellular tissue and a fold of the tunica vaginalis. The head of the epididymis is united to the testicle by several ducts, the number of which varies from ten to thirty. They form several groups, which emerge from the the corpus Highmori, and immediately afterwards become convoluted, so as to form the *head* or *globus major* of the epididymis. These vessels, which are called the *vasa efferentia*, or *coni vasculosi* (*d*), are perfectly distinct at their exit from the corpus Highmori; but after a short course in the globus major, they unite into a single canal, the numerous convolutions of which constitute the vermiform body called the epididymis. It is possible, by careful and minute dissection, to unravel this duct, the folds of which, shaped like the figure 8, are united by very dense cellular tissue. Monro, who even counted the number of its inflections, has calculated its length to be about thirty-two feet.*

It is supplied with *arteries*, and some *veins* and numerous *lymphatics* issue from it. Its *nerves* are derived from the testicular, and accompany a small branch of the hypogastric artery, which has been named the *deferential artery* by Sir Astley Cooper.

Not unfrequently a dense cord, having the same structure as the vas deferens, is found proceeding from the epididymis; this cord is the vas aberrans. (*Haller.*)

The supernumerary ducts of this nature, injected with mercury by Haller, extended for a few inches into the cellular tissue of the spermatic cord.

The Vas Deferens.

The vas deferens (*t*, *figs.* 181. 184—186.), the excretory duct of the testicle, extends from the epididymis to the ejaculatory duct (*fig.* 186.), which may be regarded as a continuation of it. It commences at the point where the caudal extremity of the epididymis becomes separated from the testicle.

The following is a description of its very complicated course. In its first or *testicular* portion it passes from behind forwards and upwards along the upper border of the testicle, almost parallel with the epididymis, from the inner edge of which it is separated only by the spermatic arteries and veins. In this first portion of its course, the vas deferens pretty closely resembles a braided cord, and is, moreover, folded a great number of times, like the canal of the epididymis.

The second, *funicular* or *ascending*, portion of the vas deferens forms part

* [The average length of the vasa efferentia is stated by Lauth to be eight inches; they diminish in size as they approach the canal forming the epididymis, which they enter at intervals of about three and a quarter inches from each other. The length of that canal is, according to the same author, about twenty-one feet.]

of the spermatic cord, and passes directly upwards towards the inguinal ring. There it is in relation with the spermatic artery and veins, which are placed in front of it, and from which it is perfectly distinct, being surrounded by an independent sheath of filamentous cellular tissue. It is convoluted at its lower part for the space of an inch or an inch and a half, but is straight in the rest of its extent. The third or *inguinal* portion of the vas deferens passes through the inguinal canal to enter into the abdomen. Like that canal, it is directed obliquely upwards, outwards, and backwards, and is from an inch and a half to two inches and a half in length. The lower margins of the obliquus internus and transversalis seem to curve over it; it crosses the epigastric artery at right angles, a little above the bend formed by that artery, where it changes its direction from horizontal to vertical: in this portion of its course, as well as in the preceding, the vas deferens forms part of the spermatic cord. The fourth or *vesical* portion.—Having arrived within the abdomen, the vas deferens leaves the vessels and nerves, proceeds vertically downwards into the pelvis, passes along the side (*fig.* 181.), and then the posterior surface (*fig.* 186.) of the bladder, in which position it is retained by the peritoneum, crosses very obliquely the fibrous cord formed by the remains of the umbilical artery, and is then directed inwards and downwards to the inferior fundus of the bladder. Having arrived opposite and internally to the entrance of the ureter into the bladder, it is directed horizontally inwards and a little forwards like the vesicula seminalis (*s*, *figs.* 181. 186.), internally to which it is situated, and gradually approaches nearer and nearer to its fellow of the opposite side, with which it seems to be joined. At the anterior extremity of the vesicula seminalis, it unites at an acute angle with the efferent duct (*c*, *fig.* 186.) of the latter, the union of the two forming the *ejaculatory duct* (*d*). In its vesical portion, for about two inches above the vesiculæ seminales, the vas deferens is considerably dilated, and at the same time its parietes become thinner.

On the inner side of the vesicula seminalis the canal still continues dilated, and is sometimes sacculated, and has a flexuous appearance. Each sacculus is formed by a small ampulla, which opens into the cavity of the canal.

The vas deferens forms, therefore, in this situation, a sort of provisional reservoir, resembling in its internal aspect and structure the vesiculæ seminales.

The *spermatic cord*, or cord of the spermatic vessels, is formed by the spermatic artery * and veins, the lymphatic vessels, the spermatic plexus of nerves, a branch of the genito-crural nerve, and the vas deferens, all being surrounded by the cremaster muscle and the common fibrous coat.

Structure. The following are the principal points concerning the structure of the vas deferens. It is harder than any other excretory duct, and it can be recognised by the touch among the other constituent parts of the cord, both in the healthy and in the diseased state, in which latter condition it may become considerably enlarged. It is perfectly cylindrical. Its bore is so small that it is almost capillary, and will scarcely admit Méjan's probe. Its parietes are thick, and contrast singularly with the fineness of its bore.

Several anatomists admit the existence of circular and longitudinal muscular fibres in this duct. Leuwenhoek demonstrated longitudinal fibres, with circular fibres beneath them. All that I have been able to discover in the human vas deferens, even by the aid of the glass, are circular. In their appearance, and kind of cohesion, they present much analogy to muscular fibres; but it is in the larger animals only, in the horse for example, that their muscularity can be clearly ascertained, and that we find distinctly a very thin longitudinal and superficial layer of fibres, with very thick and strong circular fibres beneath. The internal surface of the vas deferens is white, rough, and alveolar; its roughness is due to small and very white fibrous fasciculi, some of which are

* [Also the deferential artery, and the cremasteric branch of the epigastric artery.]

directed longitudinally, while others are circular, and which are either regularly or irregularly arranged.

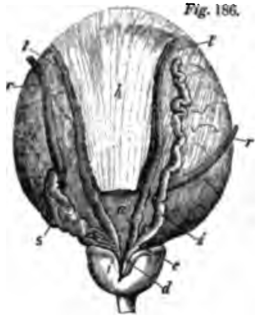
The mucous membrane lining the vas deferens is so thin that it is difficult to demonstrate it.

The Vesiculæ Seminales.

The vesiculæ seminales are two membranous pouches, which serve as reservoirs for the semen.*

They are *situated* (*s*, *fig.* 181.) between the rectum and the bladder, on the outer side of, and parallel to, the vasa deferentia. As they are directed obliquely inwards and forwards (*s*, *fig.* 186.), their anterior extremities are closely approximated, being separated from each other merely by the width of the vasa deferentia, while their posterior extremities are very far asunder; they thus form two sides of an isosceles triangle, within the area of which the bladder (*a*) is in immediate relation with the rectum. They are flattened and oblong, and are expanded at their posterior extremities, which sometimes project beyond the inferior fundus of the distended bladder, and always do so when that organ is contracted. Their anterior extremities are narrowed, and surrounded by the prostate, and their surface has a sacculated appearance. They vary in *size*, which is not always equal on the two sides; and they are much larger in the adult than in youth or old age. Their size also varies according to whether they are empty or full. They are from two inches to two inches and a half long, and about six lines broad, and two or three lines thick.

Fig. 186.



Their *relations* with the bladder and the rectum are not direct; for they are surrounded with a filamentous tissue, consisting of transverse fibres, which separates them from the neighbouring parts, and appears to me to be analogous to the tissue of the dartos.

When divided in various directions, the vesiculæ seminales exhibit a collection of cells, communicating with each other, and filled with a yellowish brown, thick, viscid fluid, very different in appearance from semen as ejaculated during life. The sacculi of the external surface, and the cells and septa of the interior of the vesiculæ, are formed by the extremely complicated convolution of a sort of intestinal tube, or narrow oblong sac, on which I have never been able to find any appendages, ramifications, or diverticula. When unravelled (as at *s*), its length varies from six to eight inches; its convolutions are attached to each other by fibrous tissue, but they may always be separated, either with or without maceration. I have seen an unfolded vesicle a foot in length; in other subjects I have seen two distinct pouches on each side, one of which was extremely small. Lastly, the internal surface of the seminal vesicles has the same rough and alveolar appearance as that of the vasa deferentia.

The *structure* of the parietes of the vesicles is also precisely the same as

* [The semen, considered anatomically, consists, according to Wagner, of *liquor seminis*, *seminal granules*, and *seminal animalcules*; the latter were discovered by Ham, and described by Leuwenhoek. In the human subject, the seminal granules are round granulated bodies, about $\frac{1}{4800}$th to $\frac{1}{3600}$th of an inch in diameter; the seminal animalcules, or spermatozoa, have an elliptical body, about $\frac{1}{9600}$th to $\frac{1}{7200}$th of an inch in diameter, and a long caudal filament: their total length is from $\frac{1}{600}$th to $\frac{1}{480}$th of an inch: their organisation is yet unknown; but in the spermatozoa of the bear, Valentin has lately observed evidences of a definite internal structure; they perform very rapid movements, which continue some hours after evacuation or removal from the body. They are not found before puberty, and then only in the vesiculæ seminales, vas deferens, and epididymis. The semen of the testis contains, besides the seminal granules, certain vesicles or cysts, in which, as shown by Wagner, the future spermatozoa are developed.]

that of the deferent vessels, excepting that the external coat is thinner; in the larger animals this coat is evidently muscular: and it appears to me to be so in the human subject also. I have in vain attempted to find the glands described by Winslow in the substance of the walls of the seminal vesicles.

Efferent ducts of the vesiculæ seminales. From the anterior extremity or neck of each vesicle, which we have said is situated in the substance of the prostate, arises a very delicate duct, the *efferent duct* (*c*) *of the vesicula seminalis*: this duct almost immediately unites with the vas deferens, the walls of which are thin and very dilatable in this situation. By the junction of the two, which occurs at a very acute angle, the *ejaculatory duct* (*d*) is formed: this passes through the prostate (which is shown divided in the figure), upwards and forwards, parallel to and in contact with its fellow of the opposite side, but without communicating with it. The ejaculatory ducts have very thin parietes, but they are tolerably wide, and very dilatable; closely applied to each other, they open separately on the enlarged extremity of the *verumontanum*, one on the right, the other on the left (*fig.* 182.).

The Penis.

The *penis*, the organ of copulation, is situated in front of the symphysis pubis. When collapsed, it is flaccid, and forms a curve with the concavity looking downwards; but during erection, it is large and hard, and forms a curve with its concavity turned upwards.

It is cylindrical when collapsed, but has a triangular prismatic form, with blunt edges, when in the opposite condition. Two of these edges are lateral, and are formed by the projection of the corpus cavernosum; the other is anterior, and corresponds with the canal of the urethra. Its posterior extremity is attached to the pubis; its anterior extremity forms a conical enlargement, called the glans, on which is seen the orifice of the urethra.

Structure. The penis consists essentially of the corpus cavernosum and the canal of the urethra, the expanded extremity of which forms the glans penis. Some proper muscles are attached to it; it receives large vessels and nerves, and it is covered by integument.

The skin of the penis and prepuce. The skin of the penis has several peculiarities: thus, it is very thin, although not so thin as that of the scrotum and the eyelids. In this respect it contrasts remarkably with the thick hairy skin which covers the cushion of adipose tissue situated over the symphysis; it is generally of a browner colour than that of the rest of the skin; it has no hair bulbs visible to the naked eye; it is extremely moveable, being capable of gliding forward upon the corpus cavernosum, of forming a covering for tumours in the scrotum, and also of folding upon itself when the penis is reduced to its smallest dimensions. This great mobility of the skin is owing to the looseness of the subcutaneous cellular tissue, which is continuous with the dartos, and appears to me to be of the same nature; like that structure, it never contains fat, but may become infiltrated with serum.

The prepuce. The skin of the penis forms a non-adherent sheath for the glans, upon which it advances, and either projects beyond it or not, according as that part is flaccid or distended. At the free border of this sheath the skin does not terminate abruptly, but is reflected upon itself, assumes the characters of mucous membrane, and passes backwards as far as the base of the glans, so as to line the inner surface of the cutaneous layer. Opposite the constriction or neck surrounding the glans, the mucous membrane or reflected skin again becomes reflected over the glans, to which it forms a closely adherent covering, and at the margin of the orifice of the urethra becomes continuous with the mucous membrane lining that canal. The non-adherent sheath which covers the glans is called the *prepuce.**

* [Beneath the mucous membrane covering the constriction behind the corona glandis, are situated clusters of small sebaceous glands, named *glandulæ Tysoni*, or *odoriferæ*.]

Sometimes the orifice of this sheath is so narrow as to prevent its being easily drawn backwards, especially during erection. This constitutes what is called *phymosis.** Circumcision, an operation which consists in removing an annular portion of the prepuce, was, as we know, a general custom among the Jews, and is now recognised among the operations of surgery.

The length of the prepuce varies in different individuals; in some it is very short, and only covers one half or the posterior third of the glans.

The term *frænum præputii* is applied to a triangular fold of mucous membrane, which is reflected from the prepuce upon the furrow on the lower surface of the glans, below the urethral orifice. Sometimes the prolongation of the frænum as far as the orifice renders erection painful, and requires a slight operation, called section of the frænum.

The cellular tissue, between the cutaneous and mucous layers of the prepuce, partakes of the characters of the subcutaneous cellular tissue of the penis; its looseness enables the prepuce to be unfolded, and this takes place more or less completely during erection.

The corpus cavernosum. The corpus cavernosum, so named on account of its structure, forms the greater portion of the penis: it commences behind by a bifurcated extremity, forming its *roots*, or *crura.* Each root arises immediately on the inside, and above the tuberosity of the ischium, by a very slender extremity, and gradually increasing in size, passes forwards and inwards along the ascending ramus of the ischium and the descending ramus of the pubes, to both of which it adheres intimately. At the symphysis the two roots unite. The triangular interval between them is occupied by the canal of the urethra.

The corpus cavernosum results, therefore, from the union of two distinct conical roots; and on this account the older anatomists distinguished two corpora cavernosa: but the communications existing between its two halves are opposed to any such distinction.

The corpus cavernosum is cylindrical, and presents a longitudinal groove above, in which are lodged the dorsal vessels and nerves of the penis, and a broad and deep groove below, in which the urethra is situated. The anterior extremity is obtuse, and is embraced by the base of the glans, with which it does not appear to have any vascular communication.

Structure. The corpus cavernosum is composed of a very strong fibrous cylinder, filled with a spongy or erectile tissue.

The fibrous cylinder. The external coat is of a fibrous nature, and is remarkable for its thickness, which is one or two lines; for its strength, which is such that the corpus cavernosum will bear the whole weight of the body without breaking, as may be proved experimentally upon the dead body; and for its *extensibility and elasticity,* properties which do not belong intrinsically to the tissue itself, but depend upon the areolar disposition of its fibres. †

Septum of the corpus cavernosum. The interior of the cavernous body is divided into two lateral halves by an incomplete septum, formed of very strong vertical fibrous columns, which are much thicker and more numerous behind than in front This median septum (*septum pectiniforme, b, fig.* 187.), between the two halves of the corpus cavernosum, is not complete: it appears to be intended to prevent too great a distension of this part during erection.

The spongy or erectile tissue. An areolar tissue (*a a*), the meshes of which contain a greater or less quantity of blood, occupies the interior of the fibrous cylinder of the corpus cavernosum. This tissue, which is the chief agent in erection, consists of an interlacement of veins, supported by prolongations or *trabeculæ,* given off from the inner surface of the fibrous membrane.

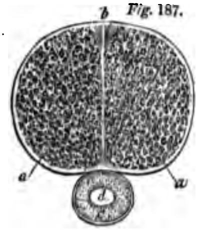
* When this malformation exists, if the prepuce be drawn back over the base of the glans it cannot be returned; this condition of the parts, and the sort of strangulation resulting from it, constitutes what is known by the name of *para-phymosis.*

† [The outer coat of the corpus cavernosum and the trabeculæ, in its interior, consist of tendinous fibres, mixed with some elastic tissue. In the penis of the horse there are pale red fibres, differing from cellular, tendinous, and elastic tissue, but which, according to Müller, do not possess muscular contractility.]

If air or any fluid be injected into the crura of the corpus cavernosum, the penis will acquire the same size as it has during erection, and the injection will pass readily into the veins; we may therefore conclude that all the cells of the corpus cavernosum communicate with each other, and further that they communicate freely with the veins. If the corpus cavernosum be distended with tallow, and then, after being allowed to dry, if the injection be dissolved out by hot oil of turpentine, we shall find that the cavernous body presents a spongy structure, analogous to that of the spleen. The several gradations from true veins to spongy tissue may be traced in the venous plexus, situated at the root of the penis. At first we find veins communicating with each other laterally, as it were by perforations; then the communications become more and more numerous; and, lastly, in the corpus cavernosum all traces of distinct vessels are lost, and nothing can be detected but a mass of cells, apparently resulting from the anastomoses of veins. The structure of the spongy tissue of the corpus cavernosum is therefore essentially venous.

A transverse section of the corpus cavernosum (*fig.*187.), after it has been prepared in the manner above indicated, exhibits an appearance of cells, somewhat resembling that seen on a section of the body of a vertebra; these cells are bounded by laminæ, which appear to be chiefly derived from the lower wall of the corpus cavernosum, on the inner surface of which is found a convexity, corresponding with the groove for the urethra (*d*). These laminæ radiate, as from a centre, to the entire internal surface of the cylinder, represented by the corpus cavernosum.

Fig. 187.



Vessels. The *veins* of the corpus cavernosum are extremely large, and are divided into the *dorsal veins* of the penis and the proper veins of the cavernous body; they all pass beneath the symphysis, and are received into fibrous canals, through which they are transmitted into the pelvis. These veins are provided with a great number of valves, so that injections thrown into the trunks cannot pass into the branches.

The *arteries* arise from the internal pudic, and enter the substance of the corpus cavernosum. Injection of these arteries does not produce erection until the fluid has passed from them into the veins.*

The *lymphatic vessels* are little known.

No *nerves* have been traced into the interior of the corpus cavernosum.†

The triangular suspensory ligament of the penis. This ligament is composed of yellow elastic tissue, and extends in the median line from the symphysis pubis to the corpus cavernosum. Muscular fibres have been described as existing in it; but it is probable some fibres prolonged from the bulbo-cavernosus, and now known as the muscle of Houston, have been regarded as forming part of this ligament. I have seen the suspensory ligament reach along the linea alba, half way up to the umbilicus.

* [Müller has described, besides the nutritious arteries of the corpus cavernosum, which terminate as usual in the veins, a peculiar set of vessels, called the *arteriæ helicinæ*. They are short curled branches, much larger than capillaries, and ending abruptly in free rounded extremities; they project either singly, or in tufts arising from one stem, into the venous cells, by the lining membrane of which they are supported and invested. They are found principally in the posterior portions of the cavernous and spongy bodies, and are more marked in man than in animals. In the horse they are very indistinct; in the elephant they do not exist at all. Müller believes that the blood, during erection, is poured out directly from these vessels into the venous cells; but no openings through which the blood could escape have been detected, either in their sides or at their extremities, nor is analogy in favour of their existence.

According to Valentin, the so-called helicine arteries are the divided branches of common arteries curled up (after having been injected), in consequence of the retraction of the elastic trabeculæ on which they are supported; to this it is replied, by Müller, that these vessels may be seen in cells deeper than the surface of the section. Valentin further maintains that the arteries terminate in the veins by wide funnel-shaped orifices.]

† [Numerous nerves enter the corpus cavernosum; they are derived from the internal pudic and sympathetic nerves, and have been carefully traced by Müller.]

Muscles of the Penis.

These are eight in number, four on each side, viz. the *ischio-cavernosus*, the *bulbo-cavernosus*, the *pubio-urethralis*, and the *ischio-bulbosus*.

The Ischio-cavernosus, or the Erector Penis.

The ischio-cavernosus (*c*, *fig.* 163.) is an elongated muscle, *situated* upon the corresponding root of the corpus cavernosum; it is curved upon itself, and is aponeurotic in part of its extent.

It *arises* from the inner lip of the tuberosity of the ischium, below the transversus perinæi, by tendinous and fleshy fibres, and also from the surface of the root of the corpus cavernosum. From these points its fibres pass inwards, and are *inserted*, after a short course, into the edges of the upper surface of a very strong, shining, and fasciculated aponeurosis, having its fibres directed from behind forwards, which covers the corresponding root of the cavernous body, upon which it is then prolonged. The fleshy fibres, terminating at the edges of the aponeurosis, form two bundles; one, internal, and extending upon the inner side of the root, the other external, which passes on the outer side of the same, and is prolonged. much further than the internal fasciculus, upon the cavernous body. In order to see the structure of this muscle, it is necessary to make a longitudinal incision into the aponeurosis, which entirely covers its lower surface; we then observe a muscular layer, which is tolerably thick behind, but thin in front, and is formed partly by the original fibres, and partly by others arising from the root of the corpus cavernosum itself.

Relations. Below, with the cellular tissue and the dartos; above, with the root of the corpus cavernosum, upon which it is closely applied; on the inside, with the bulbo-cavernosus, being separated from it by a triangular space, the base of which is directed backwards.

Uses. It acts solely upon the corpus cavernosum, drawing the root of the penis downwards and backwards; instead of compressing the root of the corpus cavernosum by the contraction of its fibres, it tends, on the contrary, to dilate its cavity, by separating the lower from the upper wall, and in this manner facilitates erection.

The Bulbo-cavernosus, or Accelerator Urinæ.

This muscle (*d*, *fig.* 163.) is much larger than the preceding; it is *situated* in front of the anus, extending along the lower surface of the bulb and the spongy portion of the urethra, upon which it seems to be moulded.

It *arises* in front of the sphincter ani by a median fibrous raphé, which is common to the two muscles of this name, and which appears to arise from the bulb, to which it adheres closely; whilst the external fibres arise from the posterior margin of the triangular ligament, or deep perineal fascia, and frequently from the rami of the ossa pubis, opposite that margin. From this double origin the fibres pass forwards, and terminate in the following manner: the outermost fibres form a thin layer upon the lower surface of the triangular ligament, and are *inserted* by short tendinous fibres to the inner side of the root of the corpus cavernosum; the middle fibres, which are larger, are directed obliquely inwards, and are *inserted* by very distinct tendinous fibres immediately in front of the point of junction of the roots of the corpus cavernosum, in the sort of groove between that body and the urethra; the innermost fibres are the longest; they pass directly forwards, and, at the point where the penis is bent in front of the pubis, are inflected outwards (*e*, *fig.* 163.), pass upon the sides of the penis, and terminate on its dorsal surface, becoming continuous with the suspensory ligament. The last named termination appears to me to constitute the muscle described by Houston; which, according to that anato-

mist, is intended to compress the dorsal veins of the penis* in man and other animals; but it is evident, on the one hand, that it cannot compress the veins of the penis; and on the other, as M. Lenoir has pointed out, that the dorsal veins of the penis are cutaneous veins, which do not communicate with those of the corpus cavernosum.†

Relations. Below, the bulbo-cavernosus corresponds with the dartos, from which itisseparated by the superficial perineal fascia by a very thin layer of fat, and by a proper fibrous sheath. Above, it is in relation with the bulb of the urethra, which it embraces, like a contractile sheath, resembling the sheath around the stems of grasses. The inner border is continuous with the muscle of the opposite side; so that, at first sight, it might be thought that there is but one bulbo-cavernosus.

Uses. Its attachment to the inner side of the corpus cavernosum enables it to separate the lower wall of that body from the upper, and consequently to induce the entrance of the blood. It therefore contributes powerfully to erection. On the other hand, by compressing the urethra, it accelerates the expulsion of the urine and semen.

The Pubio-urethralis.

This muscle, known also as the *muscle of Wilson*, because it was described by that anatomist, may be regarded as the continuation of the levator ani. The two muscles arise from the middle of the sub-pubic arch, and descend first upon the sides and then on the lower surface of the membranous portion of the urethra, which they surround as in a ring. They are situated behind the triangular ligament, or *deep perineal fascia.*‡ When spasmodically contracted, it is said that they may arrest the point of a catheter.

* [The compressores venæ dorsalis penis, according to Houston (*Dublin Hosp. Reports*, vol. v.), arise from the rami of the pubes above the erectores penis and the crura of the corpus cavernosum, expand into a thin layer, pass upwards, inwards, and forwards, and unite in a common tendinous band over the dorsal vein. They are separated by the crura from the erectores penis, of which muscles, he says, they might otherwise be regarded as portions; the anterior layer of the triangular ligament and the pudic artery are interposed between them and the muscles of Wilson.]

† Dissertation sur quelques Points d'Anatomie, de Physiologie, et de Pathologie, No. cccxv. 1833.

[The dorsal veins return the greater part of the blood from the glans penis and corpus spongiosum, as well as the skin, and are also joined by branches from the corpus cavernosum. (See M. Cruveilhier's own description of these veins; ANGEIOLOGY.)]

‡ [In the description of the muscles given by Wilson himself (*Med. Chir. Trans.* vol. i. pp. 176, 177.), it is stated, that "the line of tendon connecting the two bellies of these muscles is in general very distinctly seen running from the apex of the prostate gland, along the under surface of the membranous portion of the urethra, until it enters the corpus spongiosum penis." From this it would appear, that the muscles discovered by him are placed *between* the two layers of the ligament, not behind its posterior layer.

On the same plane with Wilson's muscles, *i. e.* between the layers of the ligament, are situated two small transverse muscles, which arise, one on each side, by broad thin tendons, from the rami of the ischia, near their junction with those of the ossa pubis, immediately above the crura penis and their erector muscles; from thence the fleshy fibres pass transversely inwards and upwards, and are inserted along the median line of the upper and under surface of the membranous portion of the urethra by means of two tendinous structures; which extend, one above the urethra, from the fascia covering the prostate to the union of the crura penis in front of the triangular ligament, and the other below that canal, from the fascia on the prostate to the central point of the perineum: to this tendinous structure the vertical muscles of Wilson are also attached. The pudic arteries run either above or below these transverse muscles, the lower fibres of which pass below Cowper's glands, *i. e.* more superficially, when viewed from the perineum.

These transverse muscles are described and figured by Santorini (*Observ. Anat.* c. x. § viii. t. 3. fig. 5.; also *Septemdecim Tabulæ*, t. 16. fig. 1.), who states, however, that they are attached only to the lower surface of the urethra, behind the bulb; he named them elevatores urethræ, or ejaculatores. It has been recently shown by Mr. Guthrie (*Lond. Med. and Surg. Journ.* 1833, pp. 491, 492.; also, *On the Anatomy and Diseases of the Neck of the Bladder and of the Urethra*, 1834, p. 34. &c.) that the transverse muscles of Santorini are inserted, as already described, both above and below the urethra; and that the vertical muscles of Wilson are blended with them at their insertions: he therefore proposes to regard them as one muscle, which has been termed the *compressor urethræ*.]

The Ischio-bulbosus.

We may describe under this name a small muscle situated below the deep perineal fascia. It is stronger than the transversus perinæi; it arises from the ascending ramus of the ischium and the descending ramus of the pubis, and terminates on the sides of the bulb. This muscle, which is of a triangular shape, is separated from the one last described by the deep perineal fascia, so that it cannot be regarded as a dependence of the levator ani.*

The Urethra.

The *urethra* is the excretory passage for the urine, and in the male it serves the same purpose in regard to the semen.

Its *direction* has been particularly studied. Commencing at the neck of the bladder, it passes forwards and downwards; having arrived beneath the symphysis pubis, it describes a slight curve, with the concavity directed upwards, embraces the symphysis, rises a little in front of it, and then enters the groove on the lower surface of the corpus cavernosum. Beyond this point its direction is determined by that of the penis; and it describes, with that organ, a second curve, much more marked than the preceding, having its concavity directed downwards, but only in the state of relaxation, for the curve no longer exists when the penis becomes elongated, either from erection, or from direct traction.

It follows, therefore, that, except during erection, the urethra describes two curves, like the letter S†; but when the penis is elongated, it forms only a single curve, which is permanent.

Although the curvature of the urethra is not so rigid as to prevent the introduction of a straight instrument into the bladder, it would be wrong to conclude that the canal itself is straight. It must be remembered that organic membranous ducts are sufficiently pliable to accommodate themselves to the direction of instruments introduced into them; but the effacing, or the artificial removal of the curves is very different from their non-existence. Moreover, the curvature of the urethra is demonstrated by the impossibility of drawing a straight line from the neck of the bladder, and passing a short distance below the symphysis to the point where the urethra joins the corpus cavernosum; also by the curve acquired by bougies after remaining for some time in the urethra; and lastly, by the curvature presented by a mould obtained by injecting the bladder and urethra with any substance capable of becoming solid.

Dimensions. The *length* of the urethra is from eight to nine inches; it is sometimes less than eight. The extreme dimensions noticed by Whately‡, in measurements taken from forty-eight subjects, are nine inches six lines and seven inches six lines. It is difficult to estimate the *width* of the urethra. According to Home, it is four lines, except at the orifice, where it is only three. It is quite impossible to judge of its width externally on account of the thickness of its walls, and especially on account of their being unequal. The extreme dilatability of the canal allows the introduction of instruments of considerable caliber, as in the operation of lithotrity.

The urethra is considered as divided into three portions, as different in their structure as in their relations; these are the *prostatic*, the *membranous*, and the *spongy portions.*

The prostatic portion. This part of the urethra, which forms, as it were, a continuation of the bladder, and the commencement of the urethra, is called

* [The description of this muscle corresponds exactly with that of the *transversus perinæi alter* of Albinus.]

† It was this direction of the canal which suggested to J. L. Petit the idea of making silver bougies, shaped like the letter S, to remain in the passage.

‡ An Improved Method of treating Stricture of the Urethra, 1816.

prostatic, because it appears to be hollowed out of the glandular body called the *prostate*, the description of which must be inserted here, on account of its intimate connection with the urethra.

The *prostate* (*i*, *fig.* 181.), a whitish glandular body, is *situated* in front of the neck of the bladder, and embraces it; it is behind the symphysis pubis, and in front of the rectum. It is shaped like a cone, with its base turned backwards, and its truncated apex forwards. Its *axis* or long diameter is horizontal, but slopes a little from behind downwards and forwards. It has often a bi-lobed appearance in man, but it is never truly double, as in a great number of animals.

The size of the prostate varies greatly in different subjects. The following dimensions have been taken from the measurements of the prostates of adults: vertical diameter twelve lines, transverse eighteen, antero-posterior, or length, fifteen. Sometimes it acquires three or four times its nominal size; the increase may affect either the whole gland, or one half, or the middle lobe only.

Relations. We shall examine the relations of the prostate with the parts corresponding to its outer surface, and with those which are situated within it.

Relations of the outer surface of the prostate. The *lower surface* corresponds with the rectum, adhering to it by tolerably dense cellular tissue, in which there is never any fat or serum; and hence the rule of examining the prostate by the rectum. In consequence of alterations in the condition of the rectum, that intestine sometimes projects on each side beyond the prostate, as during distension; and sometimes, as when it is contracted, the prostate projects beyond it laterally. The lower surface of the gland is smooth, and is traversed in the median line by an antero-posterior furrow, which is well marked in some subjects, and divides it into two equal portions.

The *upper surface* is in relation with the recto-vesical fascia (*q*, *fig.* 181.), or rather with some very strong ligamentous bundles, which extend from the pubes to the bladder, and are called the ligaments of the bladder. This surface has no immediate relations with the arch of the pubes, behind which it is placed; it is always some lines distant from it. Nevertheless, by means of a silver catheter or sound, introduced into the bladder, we may draw the prostate under the pubes, and make it project in the perineum.

The *sides* are embraced by the levator ani and levator prostatæ. When the prostate is pushed downwards by the catheter its sides are embraced by the circumference of the arch of the pubes, and they then approach very near the trunk of the internal pudic artery.

The *base* of the prostate embraces the neck of the bladder, and is prolonged a little upon that organ, so as to surround the vas deferens and the neck of the vesiculæ seminales.

The *apex* terminates behind the membranous portion of the urethra.

Relations of the prostate with the parts situated in its interior. The prostate is perforated by the urethra, by the ejaculatory ducts, and by its own excretory ducts.

The *relations of the urethra with the prostate* vary in different subjects: thus, sometimes its lower three-fourths only are surrounded by the gland, which is accordingly wanting above, and is merely grooved, not perforated by a canal; sometimes the prostate forms a complete hollow cylinder around the urethra. The portion of the prostate situated above the urethra is scarcely ever thicker than the part beneath it. In some cases, however, the urethra has been found occupying the lower part of the prostate, and only separated from the rectum by a very thin layer of glandular substance. When such is the case, the rectum is very liable to be wounded in the different steps of the operation of lithotomy.*

In the natural state the prostate does not project into the urethra; but not unfrequently we find a prominence, of greater or less size, rising from the lower

* The varieties in the situation of the urethra, in relation to the prostate, were well pointed out by M. Senn, in an inaugural dissertation in 1825. According to his observations, the portion of the prostate situated below the canal is seven or eight lines thick in the middle, and ten or eleven lines, when measured downwards and outwards.

part of the urethra, opposite the base of the prostate, and obstructing more or less completely the commencement of that canal: this tubercle was named by Lieutaud, *la luette vésicale* (*uvula vesicæ*); by Sir Everard Home, an enlargement of the middle lobe of the prostate. But, in the first place, this prominence only exists in disease; and, secondly, there is no middle lobe, unless that term be applied to the slightly grooved, and, therefore, thinner portion by which the two lateral halves of the prostate are united.

Relations of the ejaculatory ducts with the prostate. The ejaculatory ducts (*d, fig.* 186.), which lie close to each other, are received into a sort of conical canal, formed in the prostate. Some loose cellular tissue separates them from the substance of the gland, of which they are altogether independent; it was chiefly to the portion of the prostate which is situated above this canal that the name middle lobe was given by Home.

Density. The density of the prostate is considerable, and yet the tissue of this gland is friable, and can be very easily torn after having been once divided. It is of the greatest importance to remember this friability in performing the operation of lithotomy. The prostate, in fact, is the only obstacle to the extraction of the calculus; and when this gland has been divided in its antero-posterior diameter, the bladder itself may be torn with the greatest facility.

Structure. The structure of the prostate can only be properly studied in the adult. In certain cases of hypertrophy without alteration of tissue, its characters are, as it were, exaggerated. It consists of a collection of glandular *lobules*, which may be subdivided into *granules* pressed close to each other in the midst of a tissue that appears to me to be muscular, for it is continuous with the muscular coat of the bladder, and bears the most perfect resemblance to it in cases of hypertrophy. From these granules, which are generally of unequal size, small excretory ducts proceed, and unite into an irregular number of prostatic ducts, that open not upon the *verumontanum* itself, but upon its sides (see *fig.* 182.), in the whole extent of the lower wall of the prostatic portion of the urethra, or prostatic sinus. I have assured myself of the existence of these ducts and their orifices in many cases where I have found them filled with innumerable small calculi, resembling grains of brownish sand. The orifices of the prostatic ducts may be easily detected by pressing the gland, when the fluid secreted by it will be observed to exude at several points.

The membranous portion. The membranous portion of the urethra (*c, fig.* 181.) extends from the prostatic portion to the bulb, and passes upwards and forwards.* It is in relation *above* and *laterally* with the arch of the pubes, from which it is separated by some considerable veins, or rather by a sort of erectile tissue; *below* it corresponds with the rectum, but is separated from it by a triangular space, having its base directed forwards and downwards, and its apex backwards and upwards. It is generally in this triangular space that the urethra is divided in the operation of lithotomy.

Its upper concave surface is about an inch long; its lower surface is from four to six lines. This difference in length is caused by the bulb projecting backwards upon the lower surface of the membranous portion of the urethra.

This part of the canal is embraced *laterally* and *below* by the two muscular bundles which have been already described as the *muscles of Wilson;* and also by the transverse muscular fasciculi described by Santorini and Guthrie.

The spongy portion. The spongy portion (*l*) constitutes the greatest part of the length of the urethra; it commences opposite the symphysis pubis by a very considerable expansion, called the *bulb* (below *l*), and terminates at the extremity of the penis by another and still larger expansion, which constitutes the *glans penis.*

* [The membranous portion perforates both layers of the triangular ligament, about an inch below the arch of the pubes (see *fig.* 138.); but as the two layers are separated from each other below, the greater part of this portion of the urethra is included between them; a very small part is situated behind the posterior layer: both layers are prolonged over the urethra, one forwards and the other backwards.]

The *bulb* occupies the highest part of the pubic arch, and fills the interval between the crura of the corpus cavernosum. Its size varies in different individuals, and according to the state of the penis; it projects several lines below the level of the membranous portion, which is partially covered by it in this direction, and seems to open into its upper part.

As the bulb is directed very obliquely upwards and forwards, we might be inclined to consider the urethra to be much more curved than it actually is, if we judged of it only by the external appearance of the canal.

The bulb is embraced below and upon the sides by the bulbo-cavernosi muscles, which have numerous points of insertion upon it. Between these muscles and the bulb we find Cowper's glands. The bulb terminates insensibly in front, becoming continuous with the spongy portion: the angle of union of the crura of the corpus cavernosum may be assigned as its anterior boundary.

The glands of Cowper. These are two small rounded bodies (*g g*, *figs.* 168. 181, 182.) (so called after the anatomist who has given the best description of them), situated against the bulb, in contact with which they are retained by a tolerably dense layer of fibrous tissue.* From each of these glands, which are of variable dimensions, an excretory duct proceeds, and after a course of an inch and half or two inches, opens into the canal of the urethra upon the sides of the spongy portion (*c*, *fig.* 182.), passing obliquely through its parietes.†

In front of the bulb, the spongy portion of the urethra enters the groove on the lower surface of the corpus cavernosum, and is in relation below, in the first part of its course, with the bulbo-cavernosi muscles, which separate it from the cellular tissue of the scrotum, and more anteriorly with the skin of the penis.

The *glans*, so called from its shape, is the conical enlargement which forms the extremity of the penis. It is covered by the prepuce, which is united to it below by means of the frænum; its base projects considerably beyond the end of the corpus cavernosum, and forms what is called the *corona glandis.* This circular projection is grooved perpendicularly throughout its entire extent by some large nervous papillæ, which are visible to the naked eye. The base of the glans is cut very obliquely, so that its upper surface is twice as long as its lower. Below, and in the median line, the corona glandis presents a groove in which the frænum is received.

At the extremity of the glans is situated the orifice of the urethra, *meatus urinarius*, a vertical fissure, three or four lines in extent, and placed in the same line as the frænum, from which it is separated by a very short interval. Sometimes this orifice is placed exactly opposite the frænum, and, like it, is directed downwards: this malformation constitutes what is called *hypospadias.*

Internal surface of the urethra. Upon this surface (see *fig.* 182.) we find no trace of the distinction established between the different portions of the urethra, considered from without, except that the prostatic portion of the canal is of a white colour, whilst all the rest of it is of a more or less deep violet hue.

Dimensions. Opposite the prostate the urethra becomes dilated, sometimes to a considerable extent (sinus prostaticus); at the commencement of the membranous portion it suddenly contracts, and then continues cylindrical as far as the glans, where it again dilates so as to form the *fossa navicularis* (*o*), and terminates by an orifice, which is the narrowest part of the entire canal.‡

In order to obtain more exact ideas of the comparative dimensions of the different portions of the urethra, M. Amussat inflated this canal, and then carefully removed all the structures superadded to its proper parietes, so as to

* [They are placed between the two layers of the triangular ligament; the transverse muscles of Santorini cover them below, and the arteries of the bulb (*e e*, *fig.* 168.) cross above them: they are compound glands.]

† I have never seen the gland called by Littre the anti-prostatic; nor have I seen the third gland of Cowper, which is said to be situated below the arch of the pubes.

* [Three dilatations in the urethra are usually described, viz. the prostatic sinus, the sinus of the bulb, and the fossa navicularis. The first and the third of these are described above; the second is at the commencement of the spongy portion, in the inferior wall of the urethra.]

reduce the latter to the mucous membrane only, and thus leave them of almost uniform thickness, instead of being very unequal. According to this mode of appreciation, which, however, is not free from objection, he has shown that the narrowest part of the canal is the bulbous, not the membranous portion; that the canal, after being contracted opposite the bulb, again expands at the spongy portion, and then gradually contracts as it proceeds forwards. He denies the existence of a dilatation opposite the fossa navicularis; and attributes the dilated appearance of that part to the fact of the tissue of the glans being very dense, and closely adherent to the mucous membrane of the urethra, so as not to allow it to collapse, like that of the other parts of the canal.

However, the extreme dilatability of the walls of the urethra render an exact determination of its dimensions less important than might be imagined.

Besides the extensibility of the tissues, there is another anatomical condition which favours the extreme dilatability of the urethra, viz. the existence of longitudinal folds on the inner surface of the canal, which are effaced by distension. These folds must not be confounded with certain small longitudinal fasciculi which lie beneath the mucous membrane throughout the whole extent of the canal, and appear to me to be of a muscular nature. The whole of the inner surface of the urethra presents a number of oblique orifices, which lead into culs-de-sac of variable depths. These sinuses, the orifices of which are always directed forwards, are sometimes large enough to receive the extremities of bougies; they were very well described by Morgagni, and therefore they are generally called the *sinuses of Morgagni*. I have seen them more than an inch long. No glands open into them.*

The verumontanum, or crest of the urethra. The lower wall of the membranous portion of the urethra presents, in the median line, a crest, which has been named the *verumontanum*, *caput gallinaginis*, or *urethral crest* (*a* to *d*). This crest commences in front by a very delicate extremity; is directed backwards along the median line, and terminates at the anterior part of the prostatic portion by an enlarged extremity (*a*), upon which the ejaculatory ducts open by two distinct orifices. From this posterior extremity several radiated folds proceed on either side, called the *fræna* of the verumontanum, which are lost in the opening of the neck of the bladder; they were carefully described by Langenbeck. The prostatic ducts open at the sides of the verumontanum.

Structure of the urethra. A very fine transparent mucous membrane, of an epidermic character, lines the inner surface of the urethra; and is continuous, on the one hand, with the mucous membrane of the bladder, and on the other with that covering the glans. It is also continued through the ejaculatory ducts, into the vasa deferentia and the vesiculæ seminales.†

The structure of the urethra, as regards the coats external to the mucous membrane, is not the same in the different portions of the canal.

In the prostatic portion, we find the same elements as in the bladder, which seems as if it were continued into the cavity of the prostate. The deepest layer of the muscular coat of the bladder is prolonged between the mucous membrane and the prostate, while the other layers form different planes which penetrate into the substance of the gland.

The membranous portion would be more correctly denominated the muscular part of the canal, for it is surrounded by a layer of muscular fibres. A plexus of veins surrounds these muscular fibres.

The spongy portion (*l f*, *fig.* 182.; *c*, *fig.* 187.) has a similar appearance to that of the cavernous body; it is an erectile structure, composed of a fibrous frame-work, formed by numerous prolongations interlaced in all directions, so

* [One of these sinuses or lacunæ, larger than the rest, and situated on the upper surface of the fossa navicularis, is called the *lacuna magna*; they appear to be mucous crypts.]

† [It is prolonged into the ducts of Cowper's glands and the prostate, into the vesiculæ seminales, vasa deferentia, and tubuli seminiferi, and through the ureters into the uriniferous ducts; in the female it also lines the vagina, uterus, and Fallopian tubes; the whole forms the *genito*-urinary system of mucous membranes: it is covered throughout with an epithelium, which in the male generative apparatus approaches the columnar form.]

as to resemble areolar tissue. It is probable that the internal coat of the veins lines all the cells, which contain more or less blood, according to the state of the penis.

In the tissue of the corpus spongiosum, as well as in that of the corpus cavernosum are found longitudinal muscular fibres; very evident to the naked eye in the larger animals, and the existence of which appears to be shewn by the microscope in the human subject. The structure of the glans (*f f*) is exactly the same as that of the bulb, only its tissue is more dense. The corpus spongiosum urethræ does not communicate with the corpus cavernosum, although at first sight it appears to be nothing more than a continuation of it. The blunt extremity of the corpus cavernosum is evidently embraced by the base of the glans, but no communication exists between the erectile tissue composing these two bodies, so that it is possible to inject them separately.

THE GENERATIVE ORGANS OF THE FEMALE.

The Ovaries. — The Fallopian Tubes. — The Uterus. — The Vagina. — The Urethra. — The Vulva.

The genital organs of the female consist of the *ovaries*, the *Fallopian tubes*, the *uterus*, the *vagina*, and the several parts forming the vulva. With these we may include the *mammæ*, as appendages to the generative apparatus.

The Ovaries.

The *ovaries* (*ovaria*), so called on account of the small vesicular ova which they contain, are the representatives of the testicles in the male; the product secreted by both the one and the other is absolutely indispensable for reproduction. From this analogy between the ovaries and testes the ancients called them *testes muliebres* (*Galen*).

The ovaries (*a a*, *fig.* 188.) are two in number, and are *situated* one on each side of the uterus, in that portion of the broad ligament (*d d'*,) termed the posterior ala (*b*), and behind the Fallopian tube. They are retained in this position by the broad ligament, and by a proper ligament called the *ligament of the ovary* (*c*).

Their situation varies at different ages, and also according to the state of the uterus. In the fœtus, they are placed in the lumbar regions, like the testicles. During pregnancy, they are carried up into the abdomen with the uterus, upon the sides of which they are applied. Immediately after delivery, they occupy the iliac fossæ, where they sometimes remain during the whole period of life, being retained there by accidental adhesions. It is extremely common to find them thrown backwards *, and adhering to the posterior surface of the uterus.

The ovary has sometimes been found in inguinal or femoral herniæ: by descending into the labia majora, they have simulated the appearance of testicles.

The size of the ovaries varies according to age, and according as the uterus is gravid or unimpregnated, healthy or diseased. They are relatively larger in the fœtus than in the adult; they diminish in size after birth, again increase at the period of puberty, and become atrophied in old age. During the latter periods of pregnancy, they sometimes acquire double or triple their ordinary size.

The ovaries are of an oval shape, a little flattened from before backwards;

* The situation of the ovaries, behind the Fallopian tubes, prevents their displacement forwards.

they are of a whitish colour; their surface is rough, and as it were cracked, and is often covered with very dark-coloured cicatrices, which have been incorrectly regarded as remains of ruptures in their external coat, to allow of the escape of the fecundated ovum.

The ovary is free in front, behind, and above; but is attached by its lower border to the broad ligament, by its outer end to the trumpet-shaped extremity of the Fallopian tube, and by its inner end to the corresponding side of the uterus, some lines below the upper angle of that organ, by means of a ligamentous cord, called the *ligament of the ovary* (*c*); which was for a long time regarded as a canal (*ductus ejaculans*), intended to convey an ovarian fluid into the uterus. The tissue of this ligament strongly resembles that of the uterus, and seems to be a prolongation from it.*

Structure. The ovary is composed externally of a dense fibrous coat, covered by the peritoneum, which adheres so closely to it, that it cannot be detached; and, internally, of a spongy and vascular tissue, the areolæ of which seem to be formed by very delicate prolongations from the external coat; in the midst of this tissue (the stroma, from στρωμα, a bed) the Graafian vesicles are deposited. These *vesicles* vary in number from three or four to fifty. The structure of the ovary is most evident in the recently delivered female. At that time its tissue, expanded, and, as it were, spongy, appears to me to resemble that of the dartos, and is traversed by a great number of vessels. I have also seen, in recently delivered females, the ovaries from twelve to fifteen times larger than usual, and converted into a sac, having very thin parietes, which were easily torn; the ovary itself was of a spongy, vascular, and diffluent texture, in the midst of which the vesicles were seen unaltered.

The *vesicles* are nothing more than small cysts of variable size, with very thin transparent walls, adhering to the tissue of the ovary, and containing a limpid serosity, either colourless or of a citron yellow. According to Von Baër, the most superficial vesicles, which approach the expanded extremity of the Fallopian tube, contain a floating body, which was imperfectly seen by Malpighi, and constitutes the germ or ovum.†

I have often met with ovaries destitute of vesicles; but then they had undergone some change, that of induration for example. May the absence of these vesicles be regarded as a cause of sterility?

The *corpora lutea*, according to the observations of Haller, consist of the remains of vesicles that have been ruptured in consequence of the act of impregnation; they are brownish-yellow masses, of a tolerably firm consistence, and which I have found as large as a cherry-stone in females recently delivered. These bodies have been ascertained to exist in females who have never borne children, and this anomaly has been explained by supposing that they may be produced in consequence of masturbation. We would remark, however, that there is no constant relation between the existence of these bodies and the occurrence of fecundation. In some females who have had many children, no

* It has even been stated that this so called efferent duct of the ovary divides into two branches, one of which opens directly into the uterus, while the other runs along its border, and opens near the os uteri.

† [The vesicles of De Graaf vary from the size of a pea to that of a pin's head; they have two tunics, one external and vascular, the other, called the *ovi-capsule*, which, according to Schwann, is lined internally with epithelium (membrana granulosa, *Baër*). In each vesicle there is usually but one *ovum;* which at first occupies its centre, but in the mature condition approaches the inner surface of its internal coat, and surrounded by a granular covering (tunica granulosa, *Barry*), is held there by *retinacula* (*Barry*). The ovum is a perfectly spherical body, of uniform size (about $\frac{1}{120}$th of an inch in diameter); it consists of a thick but very transparent coat (zona pellucida, *Valentin;* chorion, *Wagner*), which surrounds the substance of the yolk; within the yolk is situated the *germinal vesicle* of Purkinjé (about $\frac{1}{720}$th of an inch in diameter), and within that the *germinal spot* of Wagner (about $\frac{1}{2500}$th, or $\frac{1}{3500}$th of an inch). The changes incidental to impregnation, according to Dr. Barry, commence in the germinal spot and vesicle. For further information, and for a list of works upon this subject, see *Müller's Physiology* translated by Dr. Baly, and *Wagner's Physiology* translated by Dr. Willis.]

corpora lutea can be detected, and, on the other hand, a corpus luteum has been found in a girl of five years of age.

The *bloodvessels* and *veins* of the ovary correspond exactly with those of the testicles.

Uses. Without precisely determining the part performed by the ovaries in reproduction, it may be said that they are indispensable to that function. Extirpation of these bodies is followed by sterility. And, again, ovarian fœtation proves that fecundation may occur within the ovary. The use of the Graafian vesicles in generation is not well known.*

The Fallopian Tubes.

The *tubæ uterinæ* (*f f*, *fig.* 188.) are two ducts, situated in the substance of the

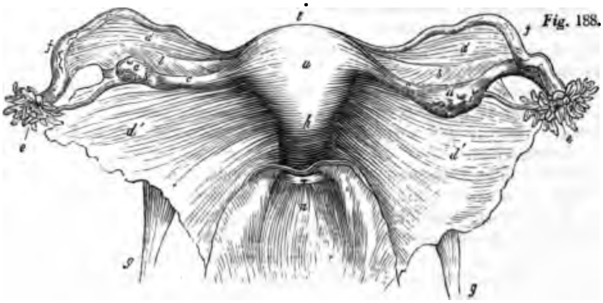


Fig. 188.

upper margin of the broad ligament. They are also called the tubæ Fallopianæ †, the Fallopian tubes, after Fallopius, who first gave a good description of them; they extend from the upper angle of the uterus to the sides of the cavity of the true pelvis.

Situation and direction. Floating as it were in the cavity of the pelvis, between the ovaries behind, and the round ligaments (*g g*) in front, they pass transversely outwards, and at the point where they terminate, bend backwards and inwards, in order to approach the outer end of the ovary, to which they are attached by a small ligament. Each Fallopian tube is straight in the inner half of its course, but describes certain windings in the remaining outer portion, which are so considerable in certain cases, and especially when the tube has been the seat of chronic inflammation or of dropsy, as to resemble in some degree the windings of the vas deferens. Moreover, accidental adhesions of the expanded extremity very frequently give it an entirely different direction from the one it usually takes. The tubes may be drawn down with the ovaries into a hernial sac, as I have several times observed.

The *length* of the Fallopian tubes is four or five inches, but it sometimes varies on the two sides. The canal in their interior is very narrow along their inner half, but gradually enlarges as it proceeds outwards to their termination, which is expanded and divided into irregular fringes, like the calyces of certain flowers: this expanded end constitutes the mouth of the trumpet, or the *fimbriated extremity* (*e*) of the Fallopian tube. In order to obtain a good view of this structure, it is necessary to place the tube in water, and then a number of fringes or small shreds of unequal length will be seen floating in the liquid, and consisting of folds divided unequally, and sometimes forming two or three concentric circles. It is generally said that one of these fringes, longer than the rest, is attached to the outer end of the ovary; but this connection appears to me to be effected by means of a small ligament. All these

* See note, page 616.
† [Literally the Fallopian *trumpets*, from their expanded abdominal extremities.]

folded fringes terminate around a circle somewhat narrower than the adjoining portion of the tube: this circle constitutes the *free orifice*, or *ostium abdominale* of the tube.

The outer portion of the tube will admit the end of a moderate-sized catheter, whilst the inner portion will scarcely admit a bristle. The diameter of that portion of the tube which traverses the uterine walls is capillary, and it is very difficult to detect with the naked eye its *uterine orifice*, or *ostium uterinum* (*o o, fig.* 189.). As the canal of the tube opens into the uterine cavity on the one hand, and into the cavity of the peritoneum on the other, it forms a direct communication between the two; and hence certain cases of peritonitis have been supposed to depend upon the passage of a fluid from the uterus into the peritoneal sac. Not very unfrequently the fimbriated orifice of the tube is obliterated; in this case the tube becomes dilated like a cone, having its base directed outwards, and it also becomes much more flexuous.

When opened longitudinally, and placed under water, the outer or wide portion of the tube presents longitudinal folds of unequal breadth, and touching by their free edges.

There is no valve, either in the course or at the orifices of the tube. Its narrow portion is hard to the touch, inextensible, and closely resembles in appearance the vas deferens; its wide portion is collapsed, and its walls are thin and extensible.

Structure. The peritoneum adheres closely to it, and forms its outer coat; it is lined by a mucous membrane, which can be easily shown in the whole extent of the broad and folded portion, and appears to form of itself the longitudinal folds already described. This lining membrane is continuous, on the one hand, with the uterine mucous membrane, and on the other, with the peritoneum, at the fimbriated extremity of the tube; it thus presents the only example in the human body of the direct continuity of a serous and mucous membrane. Between the peritoneal and the mucous coats is found a proper membrane, which appears to be a prolongation of the tissue of the uterus, and is probably muscular.*

Uses. The Fallopian tubes, which represent in the female the vasa deferentia in the male, serve not only to transmit the fecundating principle of the male, but also to conduct the fecundated ovum into the uterus. These uses are proved by the sterility of females in whom the tubes have been tied; and by the occurrence of tubal fœtations, in which the fecundated ovum is arrested in the cavity of the tube, and there passes through the several stages of developement.

The fimbriated extremity of the tube is intended to embrace the ovary during the act of fecundation, and to apply itself to the spot from which the ovum is to be detached; it follows, therefore, that any adhesion of the ovary or of the tube, which prevents this, acts as a cause of sterility.

The Uterus.

The *uterus* (*uter*, a leather-bottle), *matrix* (*mater*), or womb, is the organ of gestation.

It is *situated* (*u, fig.* 190.) in the cavity of the pelvis, in the median line between the bladder and the rectum, and is retained in that position by the round and broad ligament on each side, and by the upper end of the vagina below.

The looseness and extensibility of its connections enable it to float, as it were, in the cavity of the pelvis, and to be moved to a greater or less extent. The facility with which it can be drawn towards the vulva in certain surgical

* [Muscular fibres have not yet been demonstrated in the human subject, though in some animals circular and longitudinal contractile fibres have been found. The epithelium of the mucous membrane is columnar and ciliated; by the action of the cilia the contents of the tubes are urged towards the uterus: Dr. Henlé has found cilia on both surfaces of the fimbriæ.]

operations, and its displacement during pregnancy, when it rises into the abdomen, are proofs of its great mobility.

Direction. Its long *axis* is directed obliquely downwards and backwards, *i. e.* it coincides with the axis of the brim of the pelvis. Its direction is liable to frequent variations, the history of which belongs to midwifery; but one of them, viz. the obliquity downwards, and from the right to the left side, is so frequent that it has been regarded as natural, and, according to some anatomists, appears to be connected with the position of the rectum on the left side of the pelvis. In pregnancy this inclination is almost constant, and has some relation with the most usual position of the child, viz. that in which the occiput is turned towards the left acetabulum of the mother.

Number. The uterus is single in the human species; it is double in most animals. The cases of double uterus observed in the human subject are nothing more than bifid uteri, or such as are divided by a septum: this state may exist either in the body of the uterus alone, or at the same time in the body and neck, and even in the vagina.

Size. The size of the uterus varies according to age, and certain physiological conditions peculiar to this organ. It is very small until puberty, and then acquires the size which it subsequently presents. In females who have borne children it never returns to its original size. It becomes enormously enlarged during pregnancy, or from the developement of certain tumours. In old age it becomes atrophied, and is sometimes as small as it is in new-born infants. The following are the measurements of the uterus after puberty: — length, two and a half to three inches; breadth at the fundus sixteen to eighteen lines, at the neck six lines; antero-posterior diameter, or thickness, six lines.*

Weight. The weight of the uterus is from six to ten drachms at puberty, an ounce and a half or two ounces in females who have had children. I have seen it from one to two drachms in aged females, in whom it had become atrophied. At the end of pregnancy the weight of the uterus is from a pound and a half to three pounds.

Form. The uterus is shaped like a small gourd, or a pear flattened from before backwards. It is divided into a *body* (*u*), and *cervix* or *neck* (*h*); the distinction between these two parts being established by a more or less marked constriction.

Relations. These must be studied in front, behind, on the sides, at the upper border or fundus, and at the lower or vaginal extremity.

The *anterior surface* is covered by the peritoneum in its upper three-fourths, and is indirectly in relation with the posterior surface of the bladder, from which it is often separated by some convolutions of the small intestine; in its lower fourth it is in immediate contact with the inferior fundus of the bladder, and is united to it by rather loose cellular tissue. The latter relation explains why cancerous affections of the uterus so often extend to the base of the bladder.

The *posterior surface* is entirely covered by the peritoneum, and is in relation with the anterior surface of the rectum, from which it is often separated by some convolutions of the small intestine. This surface is much more convex than the anterior; it may be examined from the rectum.

Its *sides* are slightly concave, and give attachment to the *broad ligaments* (*d d′*, *d d′*); which are two quadrilateral folds of peritoneum, extended transversely from the lateral borders of the uterus to the sides of the pelvis. Their upper margin is divided on each side into three folds or ridges, formed in the following manner — a posterior fold formed by the ovary (*a*) and its ligament (*c*), an anterior one by the round ligament (*g*), and a middle fold by the Fallopian tubes (*f*). Hence some anatomists have described three wings (*alæ vespertilionis*) in each of the broad ligaments.

* [The body of the uterus at its thickest part, viz. immediately below the fundus, is from eight to twelve lines thick.]

The broad ligaments may be regarded as forming across the cavity of the pelvis a transverse septum, within which the uterus and its appendages are contained. This septum divides the cavity into two portions; one anterior, containing the bladder, the other posterior, in which are situated the rectum, and almost always some intestinal convolutions.

Besides the broad ligaments there are also the ligaments of the ovary and the round ligaments, proceeding from the sides of the uterus.

The *round ligaments* (*g g*) have a fibrous appearance, but are evidently continuous with the tissue of the uterus. They arise from the side of the uterus, below and in front of the Fallopian tubes, pass upwards and outwards in the anterior fold of the broad ligament, to the abdominal orifice of the inguinal canal, into which they enter, being accompanied by a prolongation of the peritoneum, which forms around them a cylindrical sheath, called the *canal of Nuck*. In females far advanced in life, this sheath may be traced as far as the external orifice of the inguinal canal.

Besides the uterine fibres which enter into its composition, the round ligament also contains a great number of veins, which may become varicose, especially near the external orifice of the inguinal canal, where they sometimes simulate a hernia.

The *upper border*, or *fundus* (*i*), of the uterus is convex, and is directed upwards and forwards; it is covered by convolutions of the small intestine; when not distended it never reaches as high as the brim of the pelvis, and cannot therefore be felt by the fingers in the hypogastric region.

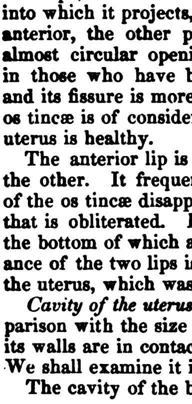
The *lower* or *vaginal extremity* of the uterus, called also the *os tincæ* from its shape, is directed downwards and backwards; it is embraced by the vagina, into which it projects, and is divided by a transverse fissure into two lips, one anterior, the other posterior. The *os tincæ* is small, and perforated by an almost circular opening (*n*), in females who have not borne children; but in those who have been mothers, it forms a more considerable projection, and its fissure is more marked and longer transversely.* In some females the os tincæ is of considerable length, and as it were hypertrophied, although the uterus is healthy.

The anterior lip is thicker than the posterior, which is a little longer than the other. It frequently happens that in old females every trace of the lips of the os tincæ disappears; the orifice alone remains, and in some cases even that is obliterated. In such a case the vagina terminates in a cul-de-sac, at the bottom of which a round and yielding point may be felt. This disappearance of the two lips is much more common than the elongation of the neck of the uterus, which was pointed out by my venerable colleague M. Lallemand.

Cavity of the uterus. The cavity of the uterus is extremely small in comparison with the size of the organ; its figure is that of a curvilinear triangle; its walls are in contact, and are smooth, and covered with a layer of mucus. We shall examine it in the body and neck of the uterus.

The cavity of the body of the uterus (*u*, *fig.* 189.) is of a triangular form, and has an opening at each angle. The inferior opening (*ostium internum*, *h*) establishes a free communication between the cavities of the body and neck; it is often obliterated in old women.† The other two orifices (*o o*) are those of the Fallopian tubes; they are scarcely visible to the naked eye, and are situated at the bottom of two funnel-shaped cavities formed at the superior angles of the uterus, and constituting the remains of the division of the body of the uterus into two halves or cornua. This division, which is normal in many animals, is sometimes met with in the human female.

Fig. 189.



* I have seen the os tincæ lacerated and fissured in different directions, in consequence of parturition.

† This obliteration, which causes retention of mucus and blood, and consequently distension and ramollissement of the body of the uterus, is so common that M. Mayer regards it as normal.

Congenital deficiency of the cavity of the uterus is very rare. My colleague, Professor Rostan, kindly sent me a specimen, in which there was no trace of a cavity in the body of the uterus, although the cavity of the neck remained. The female to whom it belonged had never menstruated. It is unnecessary to say that she was barren.

The cavity of the neck (*h* to *n*) represents a cylinder flattened from before backwards, and has upon its anterior and posterior walls certain ridges, which form upon each wall along the whole length of the neck a tolerably regular median column, from which proceed, at more or less acute angles, a certain number of smaller columns*, which project to a greater or less degree. The whole appearance resembles that of a fern-leaf, and has been called the *arbor vitæ*. It generally disappears after the first labour, at least only traces of it are left. Nevertheless, it is not unfrequently found perfect, even after several accouchements, — a circumstance of some importance in legal medicine.

The internal surface of the body of the uterus is much more vascular than the neck. This difference is particularly observed in females who have died during a menstrual period, in whom the vessels of the body of the womb are much developed, and that organ itself is swollen and softened, while the cervix retains its accustomed whiteness and consistence.

Another character of the uterine cavity is the existence of a greater or less number of transparent vesicles, which were mistaken by Naboth for ova (*ova of Naboth*), but are only muciferous follicles. They exist both in the body and neck of the uterus, but are more numerous in the neck, near the vaginal orifice, and only become apparent when the mucus accumulates in them from obliteration of their orifices. They are sometimes much enlarged, and have then given rise to the opinion that some more serious disease has existed.

The orifices of the uterine sinuses, described by the older anatomists at the fundus of the uterus, cannot be detected. They are only to be seen after delivery in the situation where the placenta had been attached.

The parietes of the unimpregnated uterus are from four to six lines in thickness. The thinnest part is at the entrance of the Fallopian tubes, where they are not more than two lines thick. The parietes of the cervix are thinner than those of the body.

Structure of the uterus. The constituent parts of the uterus are, a proper tissue, an external peritoneal coat, an internal mucous membrane, and some vessels and nerves.

The proper tissue is of a greyish colour, very dense and strong, and creaks under the knife like cartilage. The body appears less consistent than the neck, but this depends upon the fact of its being more frequently the seat of sanguineous congestion. It is composed of fibres, *i. e.* it has a linear arrangement. It may be asked, with regard to the nature of these fibres, do they consist of fibrous tissue? are they muscular, or are they analogous to the yellow tissue of the arteries? The following considerations will determine this question:—

The walls of the unimpregnated uterus appear to be composed of a fibrous tissue, traversed by a great number of vessels. During pregnancy, or in consequence of the developement of tumours, or the accumulation of fluid in the cavity of the uterus, its proper tissue acquires all the properties of the muscular tissue, as it exists in the viscera of organic life, and, like it, is endowed with contractility. Can, therefore, the presence of a fœtus or a foreign body in the uterus cause a transformation in the tissue of that organ? † Assuredly not; but the great influx of blood into the uterus, and the consequent distension and development of its fibres, reveals a structure which before was concealed by the state of condensation and atrophy kept up by inactivity.

* These rugæ, which vary considerably in their arrangement, have been described in detail by Haller, Boyer, and others.

† I conceive that I have proved by facts, that only three tissues, viz. the muscular, the nervous, and the glandular, are never the products of organic transformations. (Vide Essai sur *l'Anatomie Pathol.* 1816.)

This view is fully confirmed by the microscopical observations of Rœderer, and the chemical experiments of Schwilgué; and also by the results furnished by comparative anatomy, which has shown circular and longitudinal muscular fibres in the uteri of some animals, even when not in a gravid condition.*

The nature of the fibres of the uterus being determined, we may now examine their direction. Some anatomists agree with Malpighi and Monro, that they have no regularity in their disposition, but are interlaced in an inextricable manner. It must be confessed that, in the unimpregnated uterus, such is the case; but during gestation, the arrangement of the greater number of fibres can be traced.†

In the body the external thin layer is composed of two median vertical fasciculi, one on each surface of the uterus; of another fasciculus occupying the fundus, and of some oblique ascending and descending fibres, which converge towards the Fallopian tubes, the round ligaments, and the ligaments of the ovaries, which contain prolongations of these fibres.‡ This first, or superficial layer, belongs exclusively to the body of the uterus. The deep layer of the body consists of two series of circular fibres; each series forming a cone, the apex of which corresponds to the Fallopian tube, while the base is directed towards the median line, and is there blended with that of the opposite side.

The neck is composed entirely of circular fibres, which intersect each other at very acute angles.

The facts furnished by comparative anatomy perfectly accord with the preceding description. Thus in the uterus of a sow, which had littered, I found that the cervix was composed exclusively of circular fibres; and that the cornua (aduterum of *M. Geoffrey St. Hilaire*), which represent the body of the uterus of the human female, were formed by two layers of fibres, one external and longitudinal, the other deep and circular. From this arrangement we may therefore conclude, that the human uterus results from the union of two cornua, which communicate directly with each other, instead of opening separately into the cavity of the cervix.

When examined in the state of pregnancy, the tissue of the uterus is found to be traversed by venous canals, or *uterine sinuses*, which are of very considerable size, especially opposite the attachment of the placenta. This great number of vessels gives to the tissue of the uterus the appearance of an erectile or cavernous structure, having muscular parietes.§

The external or peritoneal coat. The peritoneum, after covering the posterior surface of the bladder, is reflected upon the anterior surface of the uterus, of which it covers only the upper three fourths, the lower fourth being in immediate contact with the bladder. At the fundus of the uterus, it passes to the posterior surface, which it covers entirely, is prolonged a short distance upon the vagina, and is then reflected upon the rectum. The broad ligaments are formed by a transverse duplicature of this coat. Two falciform folds, formed by this membrane betweeen the bladder and the uterus, are called the *vesico-uterine ligaments*, and two others, between the uterus and the rectum, are named the *recto-uterine ligaments*.

The peritoneum adheres very loosely to the borders of the uterus, but much more closely as it approaches the median line. When enlarged during pregnancy the uterus becomes covered with the peritoneum of the broad

* [The muscular fibres of the gravid uterus have been described by Dr. Baly (translation of Müller's Physiology). Like other inorganic muscular fibres, they have no transverse striæ; they are much broader than those of the alimentary canal, and taper very much at their extremities, which are sometimes split into two or three points: the corpuscules upon them are comparatively small.]

† Hunter, *Anatomia uteri*. Rosemberger in Schlegel, *Syllog. Oper. Minor. ad Artem Obstetric. Lipsiæ*, tom. ii p. 296. Mémoire présenté à l'Académie de Médecine, par Mme Boivin. Oct. *1821*.

‡ *I. e.* in the gravid state.

§ This combination of the erectile and muscular tissues is found in the penis of the horse, and, perhaps, also, in that of man.

ligament, a species of mesentery the folds of which become separated, and yield to the increasing size of the organ.

The internal or mucous membrane. The existence of a mucous membrane upon the internal surface of the uterus has been denied by those anatomists who have examined it after parturition, especially by Morgagni and Chaussier, and so, also, by those who do not admit the presence of a mucous membrane, unless it can be demonstrated over a certain space. But the existence of a mucous membrane on the internal surface of the uterus appears to me incontestably proved by the following considerations:—

First, every organised cavity which communicates with the exterior is lined by a mucous membrane; why, therefore, should the uterus form an exception to this rule. Secondly, by dissection it is shewn that the mucous membrane of the vagina is continued into the neck of the uterus, and then into the body; but in this latter situation it is destitute of epithelium.* Notwithstanding the difficulty of dissecting this membrane on account of its tenuity, and its close adhesion to the tissue of the uterus, its presence is demonstrated by the following observations: under the microscope, the internal surface of the uterus presents a papillary appearance, but the papillæ are very small; it is provided with follicles or crypts, from which mucus may be expressed by a number of points, and which form small vesicles when distended with mucus, in consequence of obstruction or obliteration of their orifices. Thirdly, it is extremely vascular, and presents a capillary net-work of the same appearance as that of the other mucous membranes; and lastly, it is constantly lubricated with mucus. Pathological observations also show, that the internal surface of the uterus, like all mucous membranes, is liable to spontaneous hæmorrhages from exhalation, without breach of continuity, to catarrhic secretions, and to those growths which are denominated mucous, vesicular, and fibrous polypi: and it is generally admitted that, where there is an identity of disease, there is also identity of structure.

During pregnancy the elements of the mucous membrane are separated; the vessels become penicillate, and greatly increased in size; but in proportion as the uterus returns to its original dimensions, the mucous membrane regains its primitive form, and its dissociated elements approach each other. It seems as if this membrane was destroyed by a true exfoliation, and then entirely reproduced.

The *arteries* of the uterus are derived from two sources; the principal, called the uterine, arise from the hypogastric; the others proceed from the spermatic or ovarian arteries to the borders of the uterus, and are distributed upon it: both sets are very tortuous.

The *veins* are remarkable for their enormous size during pregnancy and after parturition. The term *uterine sinuses* has been given to the large veins which are then found in the substance of the organ; and this term is not altogether without foundation, for these venous canals are formed by the lining membrane of the veins which adheres to the proper tissue of the uterus, just as in the sinuses of the dura mater it adheres to the fibrous tissue of that membrane.

The *lymphatics*, which have been well examined only during pregnancy and after parturition, at which time I have often seen them full of pus, are, like the veins, extremely large (see *Anat. Path.* avec planches, liv. xiv.); they form several layers in the substance of the uterus, the most superficial of which is the most developed. They terminate in the pelvic and lumbar lymphatic glands; some accompany the ovarian veins.

The *nerves*, as seen in the pregnant condition, have been well described and figured by Tiedemann. Some of them are derived from the renal plexus, and

* [The mucous membrane of the uterus contains numerous tubular glands, or crypts, resembling, in form and direction, the tubuli of the stomach, and the crypts of Lieberkuehn found in the intestinal canal. The epithelium of this mucous membrane is, according to Henlé, columnar, *and also ciliated* from the fundus to the middle of the cervix uteri; below that point *it passes into the squamous form* of epithelium found in the vagina and on the labia.]

surround the ovarian arteries; others proceed from the hypogastric plexus, and are formed by some of the anterior branches of the sacral nerves, and by branches from the lumbar ganglia of the sympathetic.

Developement. It is generally agreed that the body of the uterus is always bifid, or two-horned, in the embryo, up to the end of the third month; and that towards the end of the fourth month the two halves are united to form a single cavity. I have not observed this in the earliest periods of intra-uterine life.

During fœtal life the uterus, instead of presenting the same form as it subsequently possesses, is decidedly larger at the neck than in the body: at this period the broadest part of the uterus is its vaginal extremity.

After birth, and up to the time of puberty, the developement of the uterus is almost stationary; so that, according to the observations of Roederer, which are confirmed by Professor Duges, it is from twelve to fourteen lines long in the new-born infant, and only an inch and a half at ten years of age.

At puberty the uterus rapidly acquires its full dimensions, and at the same time becomes the seat of a periodic and sanguineous exhalation, the occurrence of which constitutes menstruation.

In old age the uterus becomes atrophied, and altered in shape; the cervix and body are separated by a much more decided constriction. These two parts of the uterus seem to become more independent of each other. The lips of the os tincæ are generally effaced in old women. The tissue of the body preserves its softness, whilst that of the neck acquires an extreme density.

The situation of the uterus is very different at different ages. In the fœtus it projects beyond the brim of the pelvis, and is in the abdominal cavity; after birth, and in consequence of the developement of the pelvis, it seems gradually to sink into that cavity. At the age of ten years the fundus of the uterus is on a level with the brim; afterwards it is lower down. In old women it is generally inclined to one side, or reversed upon the rectum.

Functions. The uterus is the organ of gestation; the fecundated ovum is deposited in its cavity, and there meets with the most favourable conditions for its developement. The uterus is also the principal agent in the expulsion of the fœtus.

The Vagina.

The vagina is a membranous canal, extending from the vulva to the uterus; it is the female organ of copulation, and also forms the passage for the menstrual blood, and the product of conception.

It is *situated* in the cavity of the pelvis between the bladder and the rectum, and is held in that situation by tolerably close adhesions to the neighbouring parts, but still is so loose that it can be everted like the finger of a glove.

Direction. It is directed obliquely forwards and downwards, *i. e.* it coincides with the axis of the outlet of the pelvis; and as the direction of the uterus corresponds with the axis of the brim, these two parts form an angle or curvature with each other, having its concavity directed forwards.

Shape and dimensions. The vagina is shaped like a cylinder, flattened from before backwards, and having its walls in contact, as may be seen upon applying the speculum. It is from four to five inches long *; sometimes it is much shorter, I have seen it as short as an inch and a half. This congenital shortness must be distinguished from the apparent shortness produced by prolapsus uteri.

The vagina is not of the same diameter throughout. Its lower orifice is the narrowest part, while its upper extremity is the widest. In females who have borne children the bottom of the vagina forms a large ampulla, in which the speculum may be moved about extensively, and in which, also, a considerable quantity of blood may accumulate during hæmorrhage. It is moreover a dilatable canal, as is proved during parturition; and is at the same time elastic,

* [From the nature of the curve formed by the vagina, its anterior wall is shorter than the posterior.]

and contracts after delivery, so as almost to return to its original dimensions. It would appear, also, to be capable of a vermicular contraction.

Relations. In front, where it is slightly concave, it corresponds to the inferior fundus of the bladder, to which it is united by very dense filamentous cellular tissue, resembling the dartos; it cannot be separated from the urethra, which appears to be hollowed out of the substance of its walls. The close adhesion of the vagina to the bladder and urethra accounts for these latter organs always following the uterus in its displacements. Behind, the vagina corresponds with the rectum, through the medium of the peritoneum in its upper fourth, and immediately in its lower three fourths. It adheres to the rectum by cellular tissue resembling the dartos, and analogous to that existing between it and the bladder, but much looser, so that the rectum does not follow the vagina in its displacement. The sides of the vagina give attachment to the broad ligaments above, and to the superior pelvic fascia and the levatores ani below, and they are in relation with the cellular tissue of the pelvis and with some venous plexuses.

Internal surface. The internal surface of the vagina is covered with an epithelium which can be very easily demonstrated, and which is prolonged as far as the os uteri, where it terminates by a sort of indented margin, in the same manner as the epithelium of the œsophagus ceases at the stomach.* This surface presents on both walls, but especially in front and near the orifice of the vulva, some transverse rugæ, or rather prominences, which very nearly resemble the irregular ridges upon the palate; they all pass from a median prominent line, which is often prolonged like a median raphé along the whole anterior wall of the vagina; the raphé on the posterior wall is not so well marked. These two median raphés are called the columns of the vagina. They are the remains of the median septum, which generally co-exists with a bifid uterus, but exists sometimes independently of it.

The transverse rugæ of the vagina are very numerous in the new-born infant and in virgins; they are partially effaced after the first labour, at the upper part of the vagina, but always remain at the lower part. These rugæ are not folds, and do not appear to assist in the enlargement of the vagina.

The *upper extremity* of the vagina embraces the neck of the uterus, upon which it is prolonged without any line of demarcation, and forms a circular trench around the os tincæ, which is deeper behind than in front.

The *lower extremity*, or opening into the vulva, presents a corrugated transverse projection in front, which is exposed by separating the labia and nymphæ; it narrows, and seems even to close the entrance of the vagina.

In virgins, the orifice of the vulva is provided with a membrane, concerning the form and existence of which there have been numerous disputes; it is called the *hymen*, and is a sort of diaphragm interposed between the internal genitals on the one hand, and the external genitals and urinary passages on the other. This membrane is of a crescentic shape, having its concavity directed forwards, and closing up the posterior and lateral parts of the vagina: it sometimes forms a complete circle, perforated in the centre. Its free margin is fringed; it varies in breadth in different individuals, and thus regulates the dimensions of the vaginal orifice. The hymen sometimes forms a complete membrane, constituting what is called imperforate vagina.

The hymen is composed of a duplicature of mucous membrane, varying in strength, and containing within it some cellular tissue and vessels. The débris remaining after its laceration constitute the *carunculæ myrtiformes*, which vary in number from two to five.

Structure. The walls of the vagina consist of an erectile spongy tissue interposed between two very strong fibrous layers, of which the external is the thicker. Around this erectile tissue we find a tolerably thick layer resembling the tissue of the dartos condensed. I cannot agree with some anatomists in admitting an identity of structure in the walls of the vagina and uterus, for in

* *[In both of these situations the epithelium does not cease, but is merely changed in its character (see notes, p. 623.).]*

no case does the vagina assume a muscular character like the latter organ. From the presence of the dartoid tissue an obscure vermicular movement may take place, and assist the elasticity of the walls of the vagina.

The posterior wall and the upper part of the anterior wall are thin; the vagina is very much thicker opposite the urethra, which seems to be hollowed out of its substance, and terminates by a rugous enlargement, which forms at the entrance of the vagina the projection already mentioned, and which is only a very dense spongy tissue.

The mucous membrane of the vagina is remarkable for the thickness of its epithelium*, for its close adhesion to the proper membrane, and for its highly developed papillæ, especially at the entrance of the passage, where the rugæ are nothing more than papillæ in an exaggerated form. The mucous follicles can be easily demonstrated.

The bulb of the vagina. Besides the spongy expansion at the orifice of the vagina, there is in front and on each side of this orifice an enlargement or cavernous body, occupying the interval between the entrance of the vagina and the roots of the clitoris. It is not very thick in the middle, where it is placed between the meatus urinarius and the union of the roots of the clitoris, but gradually enlarges from this point, and terminates below upon each side of the vagina by an enlarged extremity. The posterior wall of the vagina is the only part in which it does not exist. In position, as well as shape, it resembles the bulb of the urethra in the male.†

The constrictor vaginæ. This consists of two muscles, one on each side of the orifice of the vagina, the arrangement of which very nearly resembles that of the bulbo-cavernosus in the male. Each muscle commences in front of the rectum by an interlacement of fibres common to it, to its fellow of the opposite side, and to the sphincter ani, passes forwards under the form of a flattened band, and terminates upon the sides of the clitoris, a portion being continued above it and blended with the suspensory ligament of that body.

Relations. It is covered on the outside by the skin and the fatty cellular tissue of the labia majora; it corresponds on the inside with the bulb of the vagina, which it must strongly compress.

The proper vaginal *arteries* arise from the hypogastric. The uterine arteries also send numerous branches to the vagina.

The *veins* are very numerous, form plexuses, and terminate in the hypogastric veins.

The *nerves* are derived from the hypogastric plexus.

Developement. The rugæ of the vagina are not visible until about the end of the fifth month of intra-uterine life; from the sixth to the eighth they become much more developed than they are subsequently. The transverse rugæ are visible in the whole length of the vagina, and are placed closely to each other. The hymen does not make its appearance until about the middle of fœtal life; it is directed forwards, and is rough and jagged. It is always present.

The Urethra in the Female.

This canal, which is, as it were, hollowed out of the anterior wall of the vagina, differs considerably from the male urethra, of which it represents the membranous portion only. It is about one inch in length.

It is very difficult to determine its diameter on account of its dilatability; but it is about three or four lines when quite undilated. Its lower end is somewhat contracted.

It is directed obliquely downwards and forwards, and is slightly concave in front.

* [The epithelium in the vagina, and also in the vulva, is squamous.]

† In one subject, on the outer side of this vaginal bulb, I found a smooth sero-fibrous pouch, containing a transparent mucous fluid. A narrow canal, proceeding from this pouch, passed directly towards the entrance of the vagina. I could not find the orifice of this canal, which was probably obliterated. The same disposition existed on both sides.

Relations. *Anteriorly*, whilst behind the symphysis, it is in contact with the cellular tissue of the pelvis; opposite the symphysis, it is in relation with the angle of union of the two crura of the clitoris. The pelvic fascia, or rather the anterior ligaments of the bladder, form a half-sheath for it above, but are separated from it by numerous venous plexuses. *Posteriorly*, the canal is so closely united to the vagina, that it is impossible to separate them.

The vesical orifice of the female urethra is similar to that of the male, only there is no prostate gland.

The *internal surface* is of a deep colour, and is remarkable for certain longitudinal folds or parallel ridges, the majority of which are not effaced by distension; one of these folds is in the median line of the lower wall of the canal. We also find the orifices of mucous crypts or lacunæ, and some parallel longitudinal veins.

Structure. It is muscular and erectile, like the membranous portion of the male urethra. It is surrounded by a thick layer of circular muscular fibres, which seem to be continuous with the fibres of the bladder, some of the longitudinal fibres of that organ being prolonged upon the outside of these.* A thin layer of spongy or erectile tissue lies subjacent to the mucous membrane, which is very thin.

The Vulva.

Under the term *vulva* we include all the external genitals of the female; viz. the mons Veneris, the labia majora and minora, the clitoris, and the meatus urinarius, to which we may add the orifice of the vagina already described.

The *mons Veneris* is a rounded eminence, more or less prominent in different individuals, situated in front of the pubes, and surmounting the vulva; the prominence of this part is owing partly to the bones, and partly to a collection of fatty tissue beneath the skin; it is covered with hair at the time of puberty.

The *labia majora* are two prominent cutaneous folds, which form the limits of an antero-posterior opening, by most anatomists named the vulva. They are flattened transversely, and are thicker in front than behind; their external surfaces are covered with hairs; their internal surfaces are moist and smooth, and in contact with each other; their free borders are convex and provided with hair; their anterior extremities are continuous with the mons Veneris; their posterior extremities unite to form a commissure called the *fourchette*, which is almost always lacerated in the first labour. The interval between the fourchette and the anus constitutes the *perineum*, which is generally from eight to ten lines long. The interval between the fourchette and the entrance of the vagina is called the *fossa navicularis*.

The constituent parts of the labia majora are, a cutaneous layer, a mucous layer, both provided with numerous sebaceous follicles.† In fat persons, a great quantity of adipose tissue, a layer of dartoid tissue next the mucous membrane, and some arteries, veins, lymphatics, and nerves. They are therefore very analogous to the scrotum in the male, and, like it, are liable to serous infiltration in anasarca.

The *labia minora*, or *nymphæ*, are seen after separating the labia majora, under the form of two layers of mucous membrane; they are narrow behind,

* [The female urethra perforates the triangular ligament precisely in the same way as the membranous portion of the urethra in the male; and moreover, between the two layers of the ligament it is surrounded by muscular fibres corresponding exactly with the *compressor urethræ* in the male sex. The vertical fibres, or Wilson's muscles, were noticed by him (*loc. cit.*), descending from the symphysis, separating on the urethra, and passing around it; the transverse fasciculi, which are often very large, form together the *depressor urethræ* of Santorini, and were described and figured by that author (*Obs. Anat.*) as arising by a broad tendon from the lower part of the rami of the pubes, above the erectores clitoridis, passing obliquely upwards and inwards, and uniting with each other *above* the urethra. Mr. Guthrie has shown (*loc. cit.*) that the relations of the vertical and transverse fasciculi to each other, to the urethra, and to the layers of the triangular ligament, are precisely the same as in the male.]

† It is not rare to see small and very short hairs growing from the sebaceous follicles on the inner surface of the labia majora; they are analogous to those of the caruncula lachrymales.

where they commence upon the inner surface of the labia majora, and they enlarge gradually as they converge towards each other in front. At the clitoris, they become slightly contracted, and bifurcate before their termination. The lower division of the bifurcation is attached to and continuous with the glans of the clitoris; the upper division unites with that of the opposite side, and forms a hood-like fold above that body, called the *preputium clitoridis.*

The nymphæ are provided with very large crypts, which are visible to the naked eye, and secrete an abundance of sebaceous matter. They vary much in size, according to age: thus, in new-born infants, they project beyond the labia majora, principally on account of the imperfect developement of the latter. They also vary in different individuals; in some females being extremely small, and in others always projecting beyond the labia majora; and lastly, in different countries; for in certain African nations, among the Hottentots for example, they are of a disproportionate length, and constitute what is called in females of that race the *apron.*

The *clitoris* is an erectile apparatus, forming a miniature representation of the corpus cavernosum of the penis. Its free extremity is seen in the anterior part of the vulva, about six lines behind the anterior commissure of the labia majora, and resembles a tubercle situated in the median line, covered, as by a hood, with the upper divisions of the bifurcated nymphæ, and continuous with the lower divisions of the same. This tubercle, which, though imperforate, has been compared to the glans penis (*glans clitoridis*), is generally very small. Sometimes, however, it is very long, so as to have excited a suspicion of the existence of hermaphrodism. In one instance that came under my observation, the free part of the clitoris was two inches long, and extremely slender.

Like the corpus cavernosum in the male, the clitoris arises from the ascending rami of the ischia by two roots, which expand and converge until they arrive opposite the symphysis, where they unite and form a single corpus cavernosum, flattened on each side; this, after passing for some lines in front of the symphysis, separates from it, and forming a curve with the convexity directed forwards and upwards, and the concavity downwards and backwards, gradually becomes smaller towards its free extremity.

It has a suspensory ligament precisely resembling that of the penis, and ischio-cavernosi muscles, similar to but smaller than those of the male. We have already said that the constrictor vaginæ, which represents the bulbo-cavernosi of the penis, has a similar arrangement to those muscles, *i. e.* it passes upon the sides of the clitoris, and then becomes continued on to its suspensory ligament.

The last circumstance which completes the analogy between the clitoris and the corpus cavernosum of the penis is the reception of the canal of the urethra into the V-shaped interval formed by the union of the two crura of the clitoris.

The corpus cavernosum of the clitoris forms a longitudinal ridge between the labia majora, extending from the anterior commissure to the glans of the clitoris.

The meatus urinarius. About an inch below and behind the clitoris, we find in the median line immediately above the projecting margin of the opening of the vagina the *meatus urinarius*, or the orifice of the urethra, which constantly appears closed.

The mucous membrane of the vulva. The mucous membrane lining the vulva is continuous, on the one hand, with the skin at the internal surface of the labia majora, and with the mucous membrane of the vagina on the other; upon the labia majora and nymphæ it has a great number of *sebaceous follicles* visible to the naked eye, and yielding a cheesy odorous secretion; and also *mucous follicles*, which are most numerous near the meatus urinarius, and open into culs-de-sac, the orifices of which are visible to the naked eye, and are often large enough to admit the blunt extremity of a probe.

Development. In the fœtus the labia majora are small, and separated from each other by the nymphæ, which are much larger in proportion, and also by

the clitoris, which projects beyond them to a greater extent in the earlier periods of developement. This predominance of the clitoris is still so decided at birth, that it has occasioned mistakes concerning the sex of the infant.

THE MAMMÆ.

Number. — Situation. — Size. — Form. — Structure. — Development.

The *mammæ* or *breasts* (μαστὸς, from μάω, to seek eagerly, because the infant seeks them for the milk) are glandular appendages of the generative system, which secrete the milk, and even after birth establish intimate relations between the mother and the infant.

The important office performed by the mammæ has led zoologists to arrange in the same class, under the term *mammalia*, all animals having an apparatus for lactation. We may mention here another character peculiar to this class of animals, because it is intimately connected with the existence of mammæ, viz. that all mammalia are viviparous, that is to say, give birth to their young freed from all their fœtal envelopes.

The mammæ exist in both sexes, but are rudimentary and atrophied in the male, and belong essentially to the female.

Number. They are two in number in the human species, which is uniparous; in the lower animals they are generally double the number of the young. Examples of three or four mammæ in the human subject are very rare, and the supernumerary mammæ are generally nothing more than simple nipples, or rather masses of fat.

Situation. They are situated on the anterior and upper part of the chest, the transverse enlargement of which in the human subject is so favourable to their developement. In the lower animals they occupy the abdominal region.

They are situated on each side of the median line, over the interval between the third and the seventh ribs. They are therefore placed at the same height as the arms, and occupy this region, says Plutarch, in order that the mother may be able to embrace and support her infant while she is suckling it.

Size. In the male they are rudimentary during the whole of life; in the female until the period of puberty only, when they become much enlarged as the generative apparatus is developed more completely. They again increase in size during pregnancy, and especially after delivery; they become atrophied in old age. In some females who are still young, the size of the mammæ by no means corresponds to their stature, strength, and soundness of constitution; while, on the other hand, it is not uncommon to see thin, phthisical individuals with very large breasts. In judging of the size of the mammæ we must not confound that depending upon the gland itself with that due to fat. The largest breasts are not always those which furnish the most milk, because their extreme size often depends on an accumulation of fat, the gland itself being small. The left mamma is almost always a little larger than the right.

Form. The mammæ represent a semi-sphere surmounted by a large papilla called the *nipple*.

The skin covering the mamma is remarkably delicate. Surrounding the nipple is an *areola* or *aureola* of a pinkish hue in young girls, but of a brownish colour in most females who have borne children; it has also a rough appearance owing to a number of sebaceous glands, which yield a kind of waxy secretion that prevents the irritating action of the saliva of the infant. Morgagni, Winslow, and Meckel state, that they have observed milk to escape from them; but if there was no error in their observations, it must be admitted that by some unusual anomaly a lactiferous duct opened at the side of one of these *little glands.*

The *mammilla* or *nipple* is of a pinkish or brown colour, rough, and as it were cracked at the summit, and capable of undergoing a sort of erection; it varies in form and size in different subjects; it is either cylindrical or conical, and sometimes so short that the lips of the infant cannot lay hold of it; in certain cases it is even depressed. In the centre of the nipple we observe one or more depressions, in which the lactiferous ducts open by a variable number of orifices.

The papilla is provided also with a great number of sebaceous glands having the appearance of tubercles, and secreting a substance which prevents the nipple from being chapped by the act of sucking and the saliva of the infant.*

Structure. The breasts consist of the mammary glandular tissue and of fat.

The mammary gland. When freed from the fat by which it is surrounded, the mammary gland appears like a mass flattened from before backwards, and thicker in the centre than at its circumference, which is irregular but less so on the inside than on the outside. Its base, which is plane, and even slightly concave, rests upon the pectoralis major, and sometimes beyond it upon the serratus magnus; a continuation of the fascia superficialis separates it from these muscles, to which it adheres by very loose serous cellular tissue only, and hence it is very moveable.

The cutaneous surface of the mammary gland is very unequal, and forms alveoli filled by fat, by which means the inequalities are concealed.

The proper tissue of the gland is considerably denser than that of most glandular organs. It should be examined both during lactation, and when that function is not being performed.

In the absence of lactation the gland has the appearance of a very compact, whitish, fibrous tissue, divided into unequal lobes, which cannot be compared to any thing better than to certain fibrous tumours of the uterus. The granular structure proper to the tissue of glands is not visible during this state.

During lactation the granular structure becomes very evident. The following are the results of my observations respecting it at this period:— The glandular granules or lobules are united into small clusters, forming flattened lobes, placed one upon another. From each little lobe proceeds an excretory duct, which may be recognised by its white colour, is easily injected, and is formed by the union of a number of smaller ducts corresponding to the number of lobules. Having had an opportunity of dissecting the mamma of a female recently delivered, in which the cellular tissue between the lobules was infiltrated with serum, the lobules themselves, as it were, dissected, and the lactiferous ducts injected with yellowish coagulated milk, I found that some of the lobules were isolated, and as it were pediculated, whilst others were collected into regular or irregular clusters. In one of these clusters the lobules had a circular arrangement, small ducts proceeded from each lobule, and passing from the circumference towards the centre of the circle like radii, opened into a common efferent duct, which issued from the central point. Another cluster was elongated and swollen at intervals, and in the centre was a duct which received the smaller ducts from the several lobules. Each lobule had a central cavity, from which a worm-shaped mass of coagulated caseous matter could be expressed. When examined by the simple microscope, the parietes of these cavities had a spongy aspect like the pith of the rush, a character which I have already noticed as belonging to all glandular organs.†

The fibrous tissue of the mamma. Besides the lobules, a large quantity of fibrous tissue also enters into the structure of the gland, forms a complete

* [Sir A. Cooper has described numerous cutaneous papillæ upon the nipple and areola; they are highly vascular and nervous. He has also shown that the glands found in the areola and at the base of the nipple have branched ducts, ending in blind extremities: in the female, from one to five open on each tubercle. (*Anatomy of the Breast*, 1840.)]

† [The ultimate structure of the mammary gland consists of the terminations of the lactiferous ducts in clusters of microscopic cells within each lobule; these cells are round, and have a diameter twenty times as great as that of the capillaries which ramify upon them.]

investment for it, and then sends more or less loose prolongations into its substance, and unites the lobes together. It is to the great quantity of fibrous tissue that the hardness of the mammary gland is to be ascribed. Sometimes the enlargement of the mamma at the time of puberty is confined entirely to the fibrous tissue; in such a case the organ may acquire an enormous size, the glandular tissue disappears, and the mamma is transformed into a many-lobed fibrous mass, which has been sometimes mistaken for a degenerated lipoma.

The adipose tissue. The alveoli on the outer surface of the mamma are filled with masses of fatty tissue, which are separated by fibrous laminæ extending from the gland to the skin. The cells in which these masses are contained do not communicate with each other, and hence the frequency of circumscribed abscesses in the mamma. The relative quantities of fat and glandular tissue have an inverse ratio to each other. The great size of the mammæ in some men is owing to developement of the fatty tissue. Haller says that it is an essential element in the structure of the gland, and that he has several times seen lactiferous ducts arise from it.

The lactiferous ducts. If the mamma of a female who has died during lactation be divided, the milk will be seen to exude from a number of points, as from the pores of a sponge; these points correspond to sections of the thin, whitish, semi-transparent excretory ducts of the mammary glands, which are called *lactiferous* or *galactophorous ducts.* They arise from the lobules, and perhaps also from the fatty tissue, as was thought by Haller *; they unite successively like the veins, converge from the circumference to the centre, traverse the substance of the gland, and at length form a variable number of ducts, which reach the centre of the gland, opposite the areola. In that situation they acquire their utmost size, and form considerable ampullæ or dilatations, between which scarcely any intervals are left. According to some anatomists the number of these ampullæ is not less than twenty; I have never counted more than ten. They are of unequal size. At the base of the nipple they become contracted, straight, and parallel, and open upon its summit by orifices, which are much narrower than the ducts themselves. Thus then, although there is no reservoir properly so called in the mammary gland, the ampullæ above described may be regarded as such; with this difference only, that instead of one reservoir there are several.

The lactiferous ducts, moreover, are surrounded, both in the mammilla and opposite the areola, with a dartoid tissue, the existence of which explains the state of orgasm and erection of the nipple, as well as the expulsion of the milk in a jet when the gland is excited. There is no trace of the cavernous structure described by some anatomists as existing in the nipple. The lactiferous ducts do not communicate with each other in any part of their course; neither in their terminating canals, nor in their ampullæ, nor in their smaller ducts; this may be proved by mercurial injections, or by filling each duct with a differently coloured injection. The mammary gland, like most others, is therefore divided into a certain number of distinct compartments, which may perform their functions independently of each other.

Injections also show that the lactiferous ducts have no valves. Their structure is little known. It is generally admitted that they consist of an internal membrane continuous with the skin, and which must be analogous to the mucous membranes, and of an external fibrous coat, which I am inclined to regard as analogous to the tissue of the dartos.

The *arteries* of the mamma arise from the thoracic, especially that which is called the external mammary, also from the intercostals and the internal mammary.

The *veins* are very large, and of two kinds, subcutaneous and deep; the latter accompany the arteries, the former are visible through the skin.

The *lymphatics* are very numerous, and enter the axillary glands. The

* *[Our present knowledge of the minute structure of glands has proved the inaccuracy of this supposition of Haller.]*

older anatomists admitted a direct communication between the thoracic duct and the glandular tissue of the breast; but this opinion, suggested by the resemblance in colour between the chyle and milk, is altogether erroneous.

The *nerves* are derived from the intercostals and the thoracic branches of the brachial plexus.

Developement. The mammæ become visible after the third month of intra-uterine life. At birth they are more developed than at a subsequent period, and contain a certain quantity of milky viscid fluid. Until puberty the mammæ of the two sexes differ only in the nipple being larger, and the gland somewhat larger in the female than in the male.

In the female at puberty they gradually acquire the size which they subsequently retain, their developement coinciding with that of the genital organs. Most commonly the change precedes, but sometimes it follows, the appearance of the menses.

The mammæ of the male also participate in the developement of the generative apparatus at the time of puberty, and in some subjects even a milky secretion is formed.*

The mammæ become atrophied in old age, and are sometimes replaced by fibrous tissue; in several old women I have found the lactiferous ducts distended with a dark inspissated mucus, of a gelatinous consistence, which has enabled me to trace the ducts even to their most delicate radicles.

THE PERITONEUM.

The Sub-umbilical portion.—The Supra-umbilical portion.—General Description and Structure.

THE *peritoneum* (περὶ, around, and τείνω, to extend) is a serous membrane, which, on the one hand, lines the abdominal parietes, and on the other invests nearly all the viscera contained in the cavity of the abdomen.

As it enters into the formation of almost all the abdominal viscera, it has been already partially examined whilst describing them. It remains for us to demonstrate these parts as a whole, and for this purpose we shall suppose the membrane to commence at one particular point, and shall trace it without interruption in a circular course until we again arrive at the point from which we started.

The peritoneum is the largest and most complicated of the serous membranes; it forms, like all of them, a shut sac, the external surface of which adheres to the parts over which it is reflected, whilst its internal surface is free and smooth.

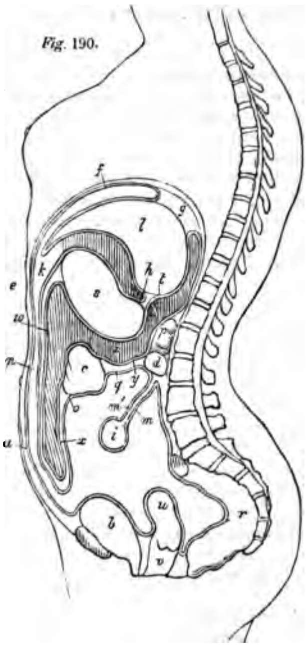
Taking the umbilical region as a point of departure, we shall divide the peritoneum into two portions, a superior, epigastric or supra-umbilical, and an inferior or sub-umbilical portion.

The inferior or sub-umbilical portion of the peritoneum. The inferior or sub-umbilical portion, supposed to commence at the umbilicus, lines the whole of the parietes of the abdomen (*a*, *fig.* 190.) below that point. In so doing it is raised up by the urachus and the two umbilical arteries, or rather by the ligaments replacing those arteries, so as to form *three falciform folds*, one median and two lateral, which converge towards their termination at the umbilicus, but diverge in the direction of the bladder; the peritoneum then dips into the pelvis, and covers the fundus, the sides, and the posterior surface of the bladder (*b*), but to a variable extent, according as that organ is distended or empty. When the bladder is contracted, the peritoneum descends behind the symphysis;

* [It has been shown by Sir A. Cooper, that the mammary gland of the male has a system of ducts and cells like those of the female gland, but very much smaller.]

when, on the other hand, it is distended and rises into the abdomen, the peritoneum retires before it, and the bladder then comes into direct contact with the anterior wall of the abdomen, so that it can be reached by the surgeon without wounding the peritoneum.

Fig. 190.



From the posterior surface of the bladder the peritoneum is reflected upon the other pelvic organs, being arranged differently in the two sexes. In the male it is reflected from the bladder upon the rectum, forming two lateral semilunar folds, called the *posterior ligaments of the bladder*, and a cul-de-sac between them of variable depth, which sometimes reaches as low as the prostate.* In the female it is reflected from the posterior surface of the bladder upon the neck of the uterus (*u*), forming a cul-de-sac between the two, so that the inferior fundus of the bladder is entirely uncovered by it. It then covers the two surfaces and the superior border of the uterus, and forms two lateral, broad, transverse folds (the *ligamenta lata*), each of which is subdivided superiorly into three smaller folds, the *alæ vespertilionis* or *alæ* of the broad ligament, the *anterior* fold corresponding with the round ligament, the *middle* one to the Fallopian tube, and the *posterior* fold to the ovary.

The peritoneum has no relation with the front of the vagina (*v*), but it covers the upper third of that canal behind; from thence it is reflected upon the rectum (*r*), and has then the same arrangement in both sexes. Inferiorly it is limited to the anterior surface of the gut, but superiorly it entirely surrounds it, excepting behind, where it forms a duplicature known as the *mesorectum.*

After leaving the cavity of the pelvis, the peritoneum continues to ascend, so as to cover the posterior wall of the abdomen; in this situation we shall examine it in the middle and at the sides.

In the middle it passes in front of the sacro-vertebral angle, then in front of the lumbar vertebræ, and having arrived opposite an oblique line, extending from the left side of the second lumbar vertebra to the right iliac fossa, it is reflected forwards to constitute the left layer (*m*) of the *mesentery* (μέσος, middle, ἔντερον, an intestine); it immediately expands, so as to correspond to the whole length of the small intestine (*i*), lines the left lateral half, the convex borders, and the right lateral half of that intestine, and then passing from before backwards (*m'*) is applied to the back of the layer just described, and in this manner forms the mesentery (*m m'*), the largest of all the duplicatures of the peritoneum, and remarkable for its resemblance to a plaited ruffle.

On the left side the peritoneum, after having formed the *mesorectum*, then forms the *iliac mesocolon*, a considerable fold, which allows great mobility to the sigmoid flexure of the colon. From the sigmoid flexure it is prolonged upon the left lumbar colon, covering the anterior five-sixths of that part of the intestine, and applying it against the kidney, but without forming any du-

* The peritoneum, forming the cul-de-sac between the bladder and the rectum, sometimes has a fissured appearance like that seen upon the parietes of the abdomen in women who have had many children.

plicature for it; so that the kidney and the colon are in immediate relation. Still the left lumbar colon is not unfrequently entirely surrounded by the peritoneum, so as to have a duplicature behind it, called the *left lumbar mesocolon.*

Along the whole course of the great intestine, the peritoneum usually forms a number of small folds containing fat, and named the *appendices epiploicæ.*

On the right side the peritoneum arrives at the cæcum, and may be arranged in one of two modes; it either entirely invests that portion of intestine, which is then very moveable; or else, and this is the most common arrangement, it passes immediately in front of the cæcum, which is thus applied against the right iliac fossa, and is attached there by rather loose cellular tissue. The peritoneum sometimes forms a small mesentery for the vermiform appendix, sometimes fixes it against the posterior surface of the cæcum, or against the ileum, or lastly against the lower portion of the mesentery. Above the cæcum the peritoneum covers the right lumbar colon, and has the same arrangements as on the left side.

Such is the course of the sub-umbilical portion of the peritoneum.

The superior or supra-umbilical portion of the peritoneum. We shall trace the superior or supra-umbilical portion from the umbilicus to the posterior wall of the abdomen, opposite to the mesentery and the lumbar mesocolon, to which points we have already traced the lower portion.

Commencing at the umbilicus and proceeding upwards, the peritoneum (*e*) lines the anterior abdominal parietes; on the right side it meets with the umbilical vein, or the fibrous cord to which that vein is reduced in the adult, covers it, and forms a falciform duplicature, named the *suspensory ligament of the liver*, or *falx of the umbilical vein;* this fold is of a triangular shape, its apex corresponds with the umbilicus, and its base with the upper surface of the liver, which is divided by it into two lateral portions or lobes.* From the umbilicus then, as from a centre, proceed four peritoneal folds, one superior or ascending for the umbilical vein, and three descending, one for the urachus and two for the umbilical arteries.

From the anterior wall of the abdomen, the peritoneum is continued upon the lower surface of the diaphragm (*f*), and is arranged differently on the right and left sides and in the middle.

The right or splenic portion. The peritoneum, after having lined the lower surface of the diaphragm as far as the vertebral column, is reflected upon the posterior surface of the vascular pedicle of the spleen, covers the posterior half of the internal surface of that organ, its posterior border, the whole of its external surface, the anterior half of its internal surface, and the anterior surface of its vascular pedicle, from which it is prolonged upon the great end of the stomach, and becomes continuous with the anterior layer of the great omentum. The two layers which are applied to each other, one in front of and the other behind the vessels of the spleen, constitute the *gastro-splenic omentum.* Below the spleen, the peritoneum forms a horizontal fold, or septum, by which that organ is separated from the viscera below it.

The middle or gastro-epiploic portion. In the middle the peritoneum lines the lower surface of the diaphragm, as far back as the cardiac extremity of the œsophagus, is reflected over the anterior surface of the stomach (*s*), and descends into the abdomen in front of the arch of the colon and the convolutions of the small intestine to form the *anterior layer* (*n*) *of the great omentum.*

After descending towards the lower part of the abdomen for a distance, which varies in different individuals and at different ages, it is folded backwards upon itself, and passes upwards to form the *posterior layer* (*o*) *of the great omentum.* Having arrived at the convex border of the arch of the colon (*c*), it covers the lower surface of that intestine, and passes horizontally backwards (*q*) to the anterior surface of the vertebral column, in front of

* [Its lower free margin incloses the umbilical vein, and its upper or anterior border is attached to the abdominal parietes.]

which it is again reflected and becomes continuous with the right layer (m') of the mesentery. The horizontal portion, which extends from the arch of the colon to the vertebral column, forms the *inferior layer* (q) *of the transverse mesocolon.*

It follows, then, that the portion of the peritoneum which is continuous with that upon the anterior surface of the stomach, forms below that organ a kind of bag, which has a direct or descending layer, and a reflected or ascending layer, in the interval between which are placed the stomach (s), the pancreas (p), the duodenum (d), and the arch of the colon (e). We shall afterwards find that each of these layers is lined internally by another layer of peritoneum, so that the great omentum consists of four layers of serous membrane.

The right or hepatic portion. On the right side the peritoneum is reflected from the diaphragm upon the convex surface of the liver (l), and forms the *coronary ligament of the liver* (at g), being continuous with the suspensory ligament, the direction of which is at right angles to its own.

From the convex surface of the liver, the peritoneum is reflected over its anterior margin, and then upon its concave surface, investing the gall bladder, sometimes almost entirely, but generally on its lower surface only. At the transverse fissure it is reflected downwards in front of the vessels of the liver, and to the left of those vessels reaches the lesser curvature of the stomach, and is continued upon the anterior surface of that organ. That portion of peritoneum which extends from the transverse fissure to the lesser curvature of the stomach, constitutes the *anterior layer* (h) *of the gastro-hepatic or lesser omentum.* To the right of the vessels of the liver and to the right of the gall bladder, the peritoneum covers the lower surface of this viscus, and becomes directly continuous with the portion which covers the right lumbar colon.

As the peritoneum is reflected from the diaphragm upon the right and left extremities of the liver, it forms two folds, one on each side, called the *triangular ligaments of the liver.*

The foramen of Winslow and sac of the omentum. Behind the vessels of the liver, and under the anterior root of the lobulus Spigelii, is an opening which leads into a cavity situated behind the stomach and the gastro-hepatic omentum. This opening is the *orifice of the omental sac*, or the *foramen of Winslow* (in which a probe is placed in the figure); the cavity is called the *posterior* cavity of the peritoneum, or the *sac of the omentum* (i). The foramen of Winslow is semicircular, sometimes triangular in shape, and about one inch in its longest diameter. It is bounded in front by the vessels of the liver, behind by the vena cava inferior, below by the duodenum, and above by the neck of the gall bladder, or rather by the lobulus caudatus, or anterior root of the lobulus Spigelii, these several parts being covered with peritoneum. Through this opening the peritoneum enters the sort of pouch formed between the two layers of the great omentum.

In tracing the course of the reflected portion of the peritoneum, we shall commence at this opening, and shall return without interruption to the same point. The peritoneum is first applied to the posterior surface of the anterior layer of the gastro-hepatic omentum already described, and forms the *posterior layer* (t) *of that omentum;* it then covers the posterior surface of the stomach; below that organ it is applied (w) to the descending or anterior layer of the great omentum, behind and parallel to which it passes down; having arrived at the point where the anterior layer of the great omentum is reflected, the layer we are now describing is itself reflected (x) in the same manner, and becomes applied to the anterior surface of the posterior layer of that omentum; continuing to ascend, it gains the convex border of the transverse colon, covers the upper surface of that intestine, and further back is applied to that layer of the great omentum which is continued over the lower surface of the colon; it thus forms the upper (y) of the two layers, of which the *transverse mesocolon* is composed. Having reached the front of the vertebral column it leaves the inferior layer of the transverse mesocolon, covers the anterior surface of the

plicature for it; so that the kidney and the colon are in immediate relation. Still the left lumbar colon is not unfrequently entirely surrounded by the peritoneum, so as to have a duplicature behind it, called the *left lumbar mesocolon.*

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From the convex surface of the liver, the peritoneum is reflected over its anterior margin, and then upon its concave surface, investing the gall bladder, sometimes almost entirely, but generally on its lower surface only. At the transverse fissure it is reflected downwards in front of the vessels of the liver, and to the left of those vessels reaches the lesser curvature of the stomach, and is continued upon the anterior surface of that organ. That portion of peritoneum which extends from the transverse fissure to the lesser curvature of the stomach, constitutes the *anterior layer* (*h*) *of the gastro-hepatic or lesser omentum.* To the right of the vessels of the liver and to the right of the gall bladder, the peritoneum covers the lower surface of this viscus, and becomes directly continuous with the portion which covers the right lumbar colon.

As the peritoneum is reflected from the diaphragm upon the right and left extremities of the liver, it forms two folds, one on each side, called the *triangular ligaments of the liver.*

The foramen of Winslow and sac of the omentum. Behind the vessels of the liver, and under the anterior root of the lobulus Spigelii, is an opening which leads into a cavity situated behind the stomach and the gastro-hepatic omentum. This opening is the *orifice of the omental sac*, or the *foramen of Winslow* (in which a probe is placed in the figure); the cavity is called the *posterior* cavity of the peritoneum, or the *sac of the omentum* (*i*). The foramen of Winslow is semicircular, sometimes triangular in shape, and about one inch in its longest diameter. It is bounded in front by the vessels of the liver, behind by the vena cava inferior, below by the duodenum, and above by the neck of the gall bladder, or rather by the lobulus caudatus, or anterior root of the lobulus Spigelii, these several parts being covered with peritoneum. Through this opening the peritoneum enters the sort of pouch formed between the two layers of the great omentum.

In tracing the course of the reflected portion of the peritoneum, we shall commence at this opening, and shall return without interruption to the same point. The peritoneum is first applied to the posterior surface of the anterior layer of the gastro-hepatic omentum already described, and forms the *posterior layer* (*t*) *of that omentum;* it then covers the posterior surface of the stomach; below that organ it is applied (*w*) to the descending or anterior layer of the great omentum, behind and parallel to which it passes down; having arrived at the point where the anterior layer of the great omentum is reflected, the layer we are now describing is itself reflected (*x*) in the same manner, and becomes applied to the anterior surface of the posterior layer of that omentum; continuing to ascend, it gains the convex border of the transverse colon, covers the upper surface of that intestine, and further back is applied to that layer of the great omentum which is continued over the lower surface of the colon; it thus forms the upper (*y*) of the two layers, of which the *transverse mesocolon* is composed. Having reached the front of the vertebral column it leaves the *inferior layer of the transverse mesocolon*, covers the anterior surface of the

third portion of the duodenum (*d*), the anterior surface of the pancreas (*p*), the lobulus Spigelii and the anterior part of the vena cava, and arrives at the transverse fissure of the liver, opposite the foramen from which we began to trace it.

It follows, therefore, that the great omentum, notwithstanding its thinness and transparency, consists of four perfectly distinct layers, two of which united together in front and two behind constitute the parietes of a cavity called the posterior cavity of the peritoneum, or the sac of the omentum.

We may, however, describe the omentum in a different mode, as follows:— Two layers of peritoneum applied to each other pass off from the transverse fissure of the liver, separate along the lesser curvature of the stomach in order to inclose that organ, again unite along its greater curvature, then pass downwards, and, opposite the brim of the pelvis, are reflected backwards upon themselves, and proceed upwards. Having reached the convex border of the colon, they separate to receive that intestine between them, become re-united at its concave border to form the transverse mesocolon, and then separate finally. The inferior layer is reflected downwards to become continuous with the right layer of the mesentery; the superior is reflected upwards to cover the third portion of the duodenum, the pancreas, and the lobulus Spigelii, and then becomes continuous with the rest of the peritoneum at the foramen of Winslow.*

General description of the peritoneum. From the preceding description it follows that the peritoneum forms a continuous membrane, so that if it were possible to unfold all its duplicatures, and to detach it entire from the surface of all the organs covered by it, it would form a large membranous sac without an opening. Nevertheless, in the female, there is a remarkable interruption at the point corresponding to the free extremity of the Fallopian tube; in which situation we find the only example in the body, of a serous and mucous membrane being continuous with each other.

The peritoneum has two surfaces, an *external* and an *internal*. The internal surface is free, smooth, and moist, and is the seat of an exhalant and absorbent process, which in the natural condition exactly counterbalance one another.

The *external* or *adherent surface* lines the parietes of the abdominal cavity, covers most of the abdominal viscera, of which it forms the external or common coat, and is in contact with itself in the different folds formed by the peritoneum. The attachment of this surface is effected by means of cellular tissue, the character of which varies in different situations.

We shall examine the external surface of the portion of the peritoneum applied to the abdominal parietes, or the *parietal peritoneum;* of that upon the viscera, or the *visceral peritoneum;* and also of that forming the different folds.

The parietal portion of the peritoneum. Upon the *diaphragm* it is attached by a very dense cellular tissue; nevertheless, it may be torn off in dissecting that part. Upon the anterior wall of the abdomen it adheres most strongly opposite the linea alba and the sheath of the rectus muscle, and more loosely opposite the crural arches than in any other part. Still it is not very difficult to separate the whole of the membrane corresponding to the parietes of the abdomen. In the *lumbar region* the adhesion is extremely loose, and also in the iliac fossæ on the front of the vertebral column: the same is the case in the cavity of the pelvis.

The cellular tissue on the outside of the peritoneum, which most anatomists have regarded as forming the external tissue of that membrane, sends prolongations through the numerous openings with which the walls of the abdomen are perforated. These prolongations connect the sub-peritoneal cellular tissue with that of the lower extremities on the one hand, and with the cellular tissue external to the pleura on the other. The peritoneum is supported throughout

* In many subjects the existence of the sac of the omentum may be demonstrated by introducing a large catheter into the foramen of Winslow, and by blowing carefully through it; the air will enter between the two anterior and the two posterior layers of the great omentum, and form a large and more or less regular bladder. For this experiment to succeed, the omentum must be perfectly uninjured, and free from adhesions.

by a *fibrous layer*, and this accounts for the difficulty with which abscesses of the abdominal parietes open into the cavity of the peritoneum.

The visceral portion of the peritoneum. Among the viscera of the abdomen some receive a complete investment from the peritoneum, always excepting the point at which their vessels reach them; to this class belong the spleen, the stomach, and the small intestines. Others have a less complete covering, so that a portion of their surface is in immediate relation with surrounding parts: of this number are the ascending and descending colon and the cæcum. Lastly, others have only very slight relations with the peritoneum, which merely pass over them, and do not appear to enter into their formation: to this class belong the bladder, the lower part of the rectum, the pancreas, the two lower portions of the duodenum and the kidneys. To the last named organs the peritoneum is connected only by very loose cellular tissue.

The visceral portion of the peritoneum is not strengthened by the fibrous layer met with in its parietal portion, and therefore, perforation of the serous coat of the viscera is much more common than perforation of the parietal portion of the serous membrane.

The folds of the peritoneum. Among the folds of the peritoneum, most of which have been already described, and which need be only recapitulated here, some bear the name of *ligaments*, viz. the triangular, coronary, and falciform ligaments of the liver, the posterior ligaments of the bladder, and the broad ligaments of the uterus.

Others are called *mesenteries*, viz. the mesentery properly so called, or the mesentery of the small intestine, the transverse mesocolon, the right and left lumbar mesocolon when they exist, the iliac mesocolon, and the mesorectum. With these we should include the duplicature extending from the transverse fissure of the liver to the lower curvature of the stomach, and known as the lesser omentum; it really constitutes the *mesogastrium*.

Lastly, there are certain folds, named *omenta* or *epiploa* (ἐπὶ, upon, πλέω, to float), viz. the great or gastro-colic, small or gastro-hepatic, gastro-splenic, and colic omenta.* With this class we may connect the appendices epiploicæ. It may be well to make a few observations upon the great and lesser omenta.

The great omentum. The great or gastro-colic omentum, so called because it is attached on the one hand to the stomach, and on the other to the colon, scarcely exists in the new-born infant; it is gradually developed as age advances, and about the period of the termination of growth it reaches to the brim of the pelvis. It has been remarked, that it descends a little lower on the left than on the right side.

When the stomach and the colon are distended, this omentum is reduced to a more or less narrow border extending along the arch of the colon.

It presents also a number of individual varieties; sometimes it is very regularly suspended in front of the intestinal convolutions; sometimes it is folded upon itself, and carried to one side or the other; occasionally it adheres at some point, becomes stretched like a cord, and may then give rise to strangulation; and lastly, it is not very rare to find it turned upwards and backwards between the diaphragm above, and the stomach and liver below.

It is so transparent and thin that it is difficult to conceive it to be formed of four layers. In some individuals, it is even perforated with holes like a piece of lace. The great omentum is found, in very fat persons, to be loaded with an immense quantity of adipose tissue, deposited chiefly along the vessels; so that it may acquire a very considerable size, and a weight of several pounds.

The great omentum has an *anterior* and *posterior surface*, both of which are free, an *upper* adherent border, a *lower* border, free, convex, and more or less sinuous, which corresponds with the crural arches, and the internal openings of the inguinal canals; it is, therefore, very often found in hernial sacs.

* [The colic omentum *consists* of two layers of peritoneum, with intermediate vessels and fat, *which descend, behind the great* omentum, from the upper part of the ascending colon.]

The lower border is more liable to adhesions than any other part of the omentum. The *lateral borders* have nothing remarkable; they proceed parallel to the ascending and descending portions of the colon, which are sometimes covered by them.

The *arteries* of the great omentum are furnished by the right and left gastro-epiploic arteries, they descend vertically between its two anterior layers, scarcely diminishing in caliber. At its lower border they turn upwards, and ascend between the two posterior layers as far as the arch of the colon, where they communicate with the arteries of that intestine.

The *veins* follow the same course as the arteries, and assist in forming the vena portæ.

Some *lymphatic glands* are found in the great omentum along the curvatures of the stomach and the arch of the colon.

Nerves. Some nervous filaments from the solar plexus can be traced upon the arteries of the omentum; it is doubtless from them that the epiploon derives its peculiar sensibility, and on them that the phenomena of strangulation depend when it is constricted in a hernia.

The *uses* of the omentum are not known.

The lesser omentum. The lesser omentum, a true mesentery, the *mesogastrium*, presents a lower concave border, attached to the lesser curvature of the stomach, and an upper border attached to the transverse fissure of the liver, to that part of the antero-posterior fissure which is behind the transverse fissure, and also to the œsophagus and the diaphragm; its right border contains the ducts and vessels of the liver, and behind the border thus formed is seen the foramen of Winslow; on the left it is bounded by the œsophagus.*

Structure of the peritoneum. The peritoneum, like all other serous membranes, has neither arteries, veins, nor nerves. Those which are contained within the omenta and the mesentery do not properly belong to this membrane. The finest capillary injections, either natural or artificial, form an extremely delicate network below the peritoneum, but never penetrate it.†

* [The cellular tissue surrounding the vessels, ducts, and nerves, contained between the layers of this small omentum, has been described as giving origin to Glisson's capsule.]

† [The basis of the peritoneum is cellular tissue; its smooth surface is covered with a squamous epithelium.]

END OF THE FIRST VOLUME.

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